UNIVERSITY OF CALIFORNIA

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The Communicative Construction of Safety in Wildland Firefighting

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Communication

by

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June 2012

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The Communicative Construction of Safety in Wildland Firefighting

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Socialization and assimilation in teams and high reliability organizations (HROs), sensemaking, learning, vocational anticipatory socialization, safety routines, wildland firefighting

ABSTRACT

The Communicative Construction of Safety in Wildland Firefighting

by

Jody Lee Shepherd Jahn

This mixed methods dissertation examined the communicative construction of safety in wildland firefighting. I used a two-study mixed methods approach, examining the communicative accomplishment of safety from two perspectives: high reliability organizing (Weick, Sutcliffe, & Obstfeld, 1999), and safety climate (Zohar, 1980).

In Study One, 27 firefighters from two functionally similar wildland firefighting crews were interviewed about their crew-level interactions involved in implementing safety rules and firefighting tasks. These critical incident narratives (Flanagan, 1954; Gremler, 2004) were compared to extract workgroup level differences in interaction patterns relating to local routines and application of safety rules for managing tasks and space. Findings revealed that the two crews differed substantially in their communicative interactions related to three specific routines: *planning*, *use of safety rules,* and *authority.* The crews also differed in their general interactions with one another related to *safety, groupness,* and *efficiency.*

For Study Two, a survey assessing workgroup-level safety climate was completed by 379 wildland firefighters. Safety climate refers to the degree to which an organization's practices emphasize safety over production pressures (Zohar & Luria, 2005). Safety climate constructs assessed in this study include: safety communication, failure learning behaviors, work safety tension, and psychological safety. Based on findings from Study One, I included additional measures to capture crew staffing patterns (dispersed, co-located), work styles (independent, task interdependent), crew prestige, and the value of a wildland firefighting routine referred to as an after action review (AAR). Hypotheses tested and modeled relationships among variables to determine how crew configurations and work styles combined to influence learning behaviors, member comfort with communicating safety concerns, and the value and acceptance of communication and learning practices.

To mix the methods from the two studies, I followed an *initiation* mixed methods design (Greene, Caracelli, & Graham, 1989), in which I examined areas of incongruence between the two studies in order to prompt new insights, and recast how safety is a communicative accomplishment in wildland firefighting workgroups.

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Introduction: Safety and Wildland Firefighting

"*The first hundred years of the wildland fire organization were about understanding fire behavior. The next hundred years will be about understanding human behavior."*

W. Waterbury, Assistant Director, US Forest Service Risk Management
(Personal communication, August 29, 2011)

In July 1994, the South Canyon fire in Colorado claimed the lives of 14 highly experienced wildland firefighters. The accident investigation report (Allen, et al., 1995) revealed that a combination of factors contributed to the event. As with previous fire fatality reports, this one chronologically listed the "facts" about how the fire unfolded. The report emphasized the extreme fire danger conditions: hot temperatures, severe drought, very low fuel moistures, steep slopes, and a predicted mid-afternoon cold front bringing high winds. The findings of the investigation report attribute the firefighters' deaths to their failure to receive critical information about fire behavior and weather, along with failing to follow several safety rules. Most of the report's safety recommendations related to ensuring that firefighters had access to fire weather information. Aside from a very brief statement that "attitudes and leadership" on the fire might have been problematic, the report did not substantively address how social dynamics might have influenced firefighter safety.

In the years following South Canyon, members of the wildland fire community debated about what actually happened on the fireline leading up to the

tragedy. The organization's position (via the investigation report) was that firefighters had "violated" several of their safety rules (the Ten Standard Firefighting orders). Firefighters were shocked and outraged that their list of safety rules was being used as a rubric for "blaming the dead" (Zeigler, 2007). Many firefighters asserted that South Canyon was an example of deeper problems throughout wildland firefighting (MacLean, 1999). Specifically, firefighters said they needed tools for managing their fireline *social* situations, especially related to leadership and understanding human performance factors such as decision-making under stress (Useem, Cook, & Sutton, 2009). In effect, the South Canyon fatalities forced the wildland firefighting organization[1] to recognize something it had previously ignored: that social dynamics have a direct influence on firefighter safety.

Research rooted in cognitive psychology and management science currently forms the foundation for the organization's efforts to use social science for informing and improving safety. These cognitive-based approaches ask how *individual* members make sense through action, generating cognitive representations of their surrounding environments which allow them to notice and bracket cues and gain understandings of cause/effect relationships (Weick, 1995). However, this literature excludes an important element in the wildland firefighting environment, namely interactions that socially construct crew organizing, especially communicative interaction that shapes expectations for how to deal with hazards, and routines for implementing safety rules. A communication perspective moves beyond attention to individual-level factors such as leadership skills and cognitive assessments. Instead,

communication focuses on *workgroup* interaction--where the organization is translated for members and where the forces of socialization and membership are the strongest (Moreland & Levine, 2001).

Communication research investigates how workgroup-level expectations for action are created as members communicatively interact, serving to influence each other's actions regarding error detection and speaking out about risk. From this view, members act in ways that are congruent to what their workgroups consider to be appropriate actions. Here, *appropriate action* is not purely based on responses to the environment, but is derived from workgroup interactions that shape what is acceptable and normative. To this end, I have conducted two studies. The first study uses an interpretive, qualitative approach to examine and compare how wildland firefighters from two functionally similar crews bring the organization's safety rules into their conversations as they decide how to take action to implement safety and conduct firefighting tasks. The second study uses a postpositivist, quantitative approach to examine how safety climate factors influence each other throughout the organization.

This chapter proceeds as follows: First, I describe the wildland firefighting context. Second, I problematize the notion of safety from two complementary theoretical lenses (high reliability organizing and safety climate). Third, I describe how the HRO and safety climate lenses are rooted in opposite research paradigms, and propose that examining wildland firefighter safety from both paradigms can provide a more complete picture than by adopting only one. Finally, I describe my

use of an initiation mixed methods design (Greene, Caracelli, & Graham, 1989), and preview the two complementary studies conducted for this dissertation project.

The Wildland Firefighting Context

Wildland firefighting entails a delicate balance between providing swift fire suppression responses and designing careful safety backup plans. Safety is difficult to implement in wildland firefighting due to three primary factors: 1) the fire environment changes in sudden and unexpected ways, 2) firefighters must navigate complex organizational structures which means that tasks and relationships of authority might often be unclear, and 3) a wide mix of skills or experience among firefighters can hinder their efforts to coordinate with each other knowledgeably. This section describes communication-related issues that emerge from these three sources of complexity.

Fire Environment

The most basic source of complexity in wildland fire is the fire itself. Wildland fires vary greatly in size from one single lightning-struck tree to hundreds of thousands of acres (National Wildfire Coordinating Group [NWCG], 2004). Fires can increase in size quickly and unexpectedly. Fires burn in a wide variety of fuel types and terrain. Some fires are swiftly moving grass and brush fires that burn sweeping expanses of flat or rolling rangeland (e.g., deserts of Utah and Nevada), while other fires burn in rugged timbered areas (e.g., forests and wilderness areas of Idaho and Montana). Because there are numerous combinations of terrain and fuel, fire conditions vary widely from one geographic region and fuel type to the next. The

changing fire conditions challenge firefighters to quickly gain proficiency with noticing emerging hazards, and adapting to unexpected events. Noticing and making sense of environmental cues is well researched in cognitive-based domains (Weick, 1995; Weick, Sutcliffe, & Obstfeld, 2005). However, a communication perspective recognizes that crews—rather than individuals—conduct firefighting tasks. Communication-based issues include: 1) understanding crew-level routines for anticipating and responding to hazards, 2) examining how members interact to communicate concerns with each other, and 3) exploring how members negotiate to develop and adapt their firefighting plans as fire conditions change.

Organizing Structures

The wide variety of wildland firefighting circumstances requires forms of organizing that can easily respond to emerging fires, and adapt to changing conditions. Thus, the second source of complexity in wildland firefighting is the organization that emerges to fight the fire. There are two phases of organizing for wildland firefighting that dictate the command structure of the fire, and as a result, inform what a crew's role will be. These phases include *initial attack* and *extended attack. Initial attack* refers to the first contact with a fire. According to the *Fireline Handbook,* "Initial attack is the action taken by resources that are first to arrive at an incident. All wildland fires that are controlled by suppression forces undergo initial attack. The kind and number of resources responding to initial attack varies depending upon fire danger, fuel type, values to be protected, and other factors. Generally, initial attack involves a small number of resources, and incident size is

small" (NWCG, 2004, p. 81). Some fires remain small, last a short amount of time (a few hours to a few days), and do not require many resources. Initial attack fires have a relatively simple command structure because they involve few firefighting resources.[2] If a fire grows in size it requires the organization to configure itself for *extended attack.* Extended attack refers to "the phase of the incident when initial attack capabilities have been exceeded" (NWCG, 2004, p 110). It is important to emphasize that the transition from initial attack to extended attack often is precipitated by an unexpected (or predicted) blowup.[3]

The *Fireline Handbook* notes that the transition between initial attack and extended attack should be carefully monitored because there is increased potential for accidents and injuries (NWCG, 2004). Potential for accidents during this transition is high due to the increased fire behavior, and also due to the implementation of a new command structure. The extended attack command structure often involves an incident management team[4] that makes all of the tactical decisions; these tactical decisions might be implemented by as many as several hundred firefighting resources (sometimes a thousand or more people) on a single fire incident. Confusion can arise as firefighters navigate a large, ad-hoc incident command structure staffed by people they have never before worked with or met. In this situation of working with unknown people to conduct high hazard tasks, firefighters must have the communication skills that enable them to advocate for themselves when they are caught in problematic trajectories of action (Barton & Sutcliffe, 2009). A communication perspective lends insight to ways that members navigate interactions

with unknown (and untrusted) supervisors and subordinates. Specifically, communication research examines how members turn their communication into *action* (Cooren & Taylor, 1997) in order to assert authority, advocate a plan that becomes implemented, or to voice dissent to refuse another person's plan.

Wildland Firefighters

The third source of complexity in wildland firefighting includes the array of skills required for firefighting work, and the distribution of various skills across different specializations. This section describes the basic training that all wildland firefighters receive, followed by brief explanations of the six firefighting specializations. I argue that the wide range of skill levels across the organization, the demands for highly specialist domains of knowledge beyond basic firefighting skill (e.g., working with complex aircraft), and high expectations for firefighter performance all combine to generate expectations that firefighters should privilege action and productivity, sometimes at the expense of safety. Further, I propose that a communication perspective provides ways to investigate how workgroup-level communicative interactions perpetuate expectations for productivity, pressure members to use specialist knowledge, and encourage (or discourage) members to take safe actions.

Red Card training. The minimum training required to work as a wildland firefighter is referred to as *Red Card*[5] training; it is a week-long training course that teaches basic information about how fire behaves in relation to different fuel types, weather conditions and topographical features (NWCG, 2008). Firefighters also learn

the wildland firefighting safety rules and guidelines: The Ten Standard Firefighting Orders, and the 18 Situations that Shout Watchout (among others). The training week culminates in a field exercise in which students are grouped into crews to practice fire assessment and fireline construction skills on a controlled burn (ignited for the purpose of the training). At the conclusion of the week, firefighters are issued a red paper card, or qualification, to fight wildland fire.

The basic firefighter training course is brief, primarily conducted in a classroom, and involves limited direct engagement with active wildland fire; therefore students become "qualified" to fight fire as a result of completing the course, but their training is relatively cursory. Newcomers to firefighting are not capable of functioning independently in the firefighting environment. Instead, they wholly rely upon their workgroups to teach them "the ropes" with regard to how to implement safety rules, as well as appropriate ways to conduct tasks. In a large organization, there are numerous ways that workgroups might translate the organization's safety rules into action or perform tasks. While existing cognitive perspectives emphasize how individual assessments of environments and hazards contribute to safety, a communication perspective roots safety implementation in social interactions whereby ongoing workgroup-level communication among members defines ideas for what constitutes "appropriate" action with regard to firefighting tasks and safety. Therefore, freshly red-carded firefighters rely heavily on their workgroups to translate the significance of events unfolding in the fire environment in addition to how the organization's safety rules should be enacted. In

other words, learning about fire is a socially—specifically, a *communicatively*--mediated activity.

Specializations. There are six primary types of wildland firefighting crews; these include engines, helitack, heli-rappel, smokejumpers, hotshot crews, and Type 2 hand crews (NWCG, 2004; USFS, 2008). The least specialized of crew types is the Type 2 hand crew. This designation is a catch-all for a variety of minimally qualified crews including prison inmate crews, private contract crews, and ad hoc crews consisting of fire-trained employees from federal agencies who fight fire on an as-needed basis (e.g., timber markers, trail crew members, seasonal hydrology technicians, etc.). The purpose of Type 2 crews is to use basic hand tools such as shovels, Pulaskis,[6] and chainsaws to dig fireline.[7] For extended attack, hotshot crews (designated as "Type 1" crews, described below) tend to work next to the active fire digging fireline. This activity is referred to as building *direct* fireline, because firefighters work *directly* next to the flames. Type 2 handcrews also spend a large amount of time conducting fire suppression activities on extended attack fires, but they tend to work in less active areas of the fire. Instead of building direct fireline like the hotshots do, Type 2 hand crews commonly perform such activities as *mop-up*[8] or *cold trailing.*[9]

In contrast to Type 2 crews, hotshot crews and some helitack/rappel crews are designated as Type 1 crews. The designation of "Type 1" or "Type 2" crew corresponds to a variety of criteria, including clearly-specified performance expectations. The *Fireline Handbook* (NWCG, 2004) provides a table indicating that

Type 1 crews should out-perform Type 2 crews by 40 percent (see Figure 1). That is, Type 1 crews are expected to produce 40 percent more fireline than Type 2 crews in a given span of time. These production expectations may push certain types of crews to want to accomplish more work than other crews do. A communication perspective investigates this issue by exploring how workgroup interactions privilege or marginalize certain behaviors. For example, if members take pride in their crew's demanding fireline construction rates, then it is possible that members will feel pressure to be highly productive at the expense of implementing adequate safety. Communication research explores sources of production pressure by examining how workgroup members interact to develop routines for action, how those routines are perpetuated over time, and how past patterns of action set a precedent—or expectations—for future actions. Patterns of action directly contributing to production pressure might include praising members who take bold actions, or a crew's normative tendency to compete with other crews to see which one can construct more fireline.

Finally, in addition to production expectation, some firefighting specialties must acquire advanced skill sets above and beyond their firefighting skills. For example, helitack and heli-rappel crews required that members gain extensive knowledge about the aerodynamics of flight, the capabilities of different models of helicopters, and factors that affect how much weight a helicopter can carry. Extensive knowledge about helicopters is essential in order to safely coordinate missions. On large fires, helitack coordinate all cargo and personnel flights, supervise when

helicopters takeoff and land, track aircraft movements, and coordinate radio communication among all aircraft on the fire. Helitack often are scattered throughout the fire to fulfill various missions, such as staffing suitable landing zones, known as helispots, where passenger and cargo missions take place.

Acquiring an additional skill-set can enhance firefighter knowledge through exposure to new experiences. However, a new skill set can be problematic when safety concerns in one domain compete with safety concerns in the other. For example, managing helicopters and fighting fire both place a premium on safety, but in different ways. Helitack and firefighting activities require specific ways of assessing the safety of land features. Helitack duties require that firefighters see terrain features for the characteristics that provide a safe landing area, while firefighting duties require firefighters to see the same terrain features for its potential escape routes, safety zones, and potential for fire behavior. At times, these safety considerations might compete with each other. For example, helitack ideally select landing areas that are safe for the helicopter in addition to being in close proximity to safety zones, thus providing for both helicopter and firefighting safety. However, terrain and other factors may mean that it is not possible to meet both of those goals. Helicopters are dangerous machines, and safe landing areas must be carefully selected. Therefore, there might be situations in which a helitack member accepts a calculated risk to use a landing zone that is safe for the helicopter but unsafe in relation to the fire (e.g., it is far away from safety zones).

Given competing skill sets, a communication perspective acknowledges the physical materiality of spatial environments to examines how workgroups develop routines for implementing safety and tasks in physical landscapes. Also, because competing safety concerns might place members in situations in which their safety is compromised, a communication perspective 1) examines how members incorporate their close-call experiences into their workgroup routines (e.g., to improve taken-for-granted methods for conducting tasks); and 2) investigates whether and how workgroups engage in learning-based discussions, and how these discussions contribute to (or are an outcome of) the workgroup's overall communication environment. The next section describes how safety can be investigated as a communication-based issue from two complementary theoretical perspectives.

Safety as a Theoretical Problem

The previous section introduced the wildland firefighting organization, outlining three central sources of complexity: the fire environment, the organizational structures, and the job's tasks. These types of challenges are not unique to wildland firefighting--several organizations face similar threats to safety. As such, there are emerging bodies of research and theory that can be applied to the wildland firefighting context. Two such theoretical perspectives include high reliability organizing (HRO) and safety climate. These perspectives problematize safety in different ways, each pointing to particular conditions that pose hazards, and mechanisms that contribute to safety. In this section, I first describe each perspective,

explain how a communication lens is useful for investigating the wildland firefighting context, and propose a two-study mixed methods project.

Two Safety Perspectives: High Reliability Organizing and Safety Climate

HRO perspective. A high reliability organization (HRO) perspective assumes that organizing processes occur under conditions that, like wildland fire, are characterized by fluctuating environments or complex organizational structures (Rochlin, 1993). Based on these ambiguous conditions, threats to safety arise when hazards go unnoticed or errors accumulate. Therefore, this perspective considers that the central mechanisms for safety are those that contribute to consistently error-free organizing processes. Research examines how member actions and interactions yield consistent patterns for anticipating, noticing, managing and learning about difficult-to-detect hazards (Weick, 1987; Weick & Roberts, 1993). Theories infer how organizing-in-the-small is recursively related to organizing-in-the-large. That is, theory-building related to HROs identifies how local learning becomes available to the broader organization; and likewise, how the organization's body of knowledge (particularly from accidents) can become relevant and accessible to members in their everyday actions. For instance, wildland firefighters' safety rules comprise the organization's body of knowledge derived from fatality accidents (Zeigler, 2007). Thus, it is important to understand the routines by which firefighters enact the rules, and in doing so, put the organization's body of knowledge into action.

The HRO perspective assumes that organizing processes occur under conditions in which environments are defined by complexity or flux, and hazards are

easy to overlook (Weick, 1987; Weick & Roberts, 1993). Qualitative research on systems and culture, coordination and sensemaking all devote enormous attention to unpacking the intricacies of the social group to descriptively explain *how* reliability is possible given social enablers and constraints. A communication perspective focuses on ways that organizational elements (e.g., rules and routines) are instantiated and perpetuated (Taylor & Van Every, 2000) to enable and constrain reliably safe action. Communication research examines how routines become sustained at local levels, how rules or routines function in member interactions, and how patterns of interaction develop over time (Bencherki & Cooren, 2011). Qualitative methods are well-suited to unpacking these communicative interactions.

Safety climate perspective. Like the HRO perspective, the safety climate perspective takes safety as its central problem. Safety climate studies, which originated in manufacturing contexts, are particularly concerned with factors in the work process that discourage safe action (Zohar, 1980; Zohar & Luria, 2005). This perspective assumes that organizing processes occur under conditions in which high rates of production or output are prioritized. Safety climate studies have focused on the context in which behaviors and interactions occur (Schein, 1992), assessing how social and production pressures in the work context influence action (Guldenmund, 2000; Zohar, 1980). Safety climate research typically assumes that workers are motivated to engage in safety conscious behaviors when they believe that their efforts at safety are important or valued (Morrow, et al., 2010); researchers take particular interest in factors that inhibit safe actions. In this context, the primary obstacles to

safety are attitudes contributing to social climates that de-value safety or that discourage the implementation of it. While cognitive-based approaches on safety climate focus on attitudinal measures, a communication-centered approach examines how supervisors and subordinates interact in ways that prioritize and produce safe (or unsafe) actions.

Safety climate is well-suited for investigating the wildland firefighting context. As previously discussed wildland firefighters face time pressure when responding to quickly changing fire environments, and crews might praise or encourage their members to push their productivity at the expense of safety. A safety climate perspective can be fruitfully applied to wildland fire workgroups in order to assess how various factors influence the communication environment of the crew. Specifically, this research perspective can be used to assess such issues as: how staffing patterns (co-located, dispersed) and work styles (independent, task interdependent) influence the degree to which workgroups engage in communication-based learning activities; and the extent to which regular engagement in communication activities influences how freely members feel they can communicate safety-related questions, concerns or insights in-the-moment.

The next section describes the two-study mixed methods approach used for this dissertation project. The chapter concludes with an overview of the dissertation as a whole.

A Mixed Methods Approach

The focus of this two-study dissertation is to examine the central role of communication in shaping wildland firefighting workgroup environments, and the workgroup routines that enact tasks and safety. I use a mixed methods approach, conducting two studies within different paradigms to examine the central concept of safety in wildland firefighting. Mixed methods research designs use a combination of qualitative and quantitative methods to understand a phenomenon more completely than one single method would allow (Greene, et al., 1989; Leech & Onwuegbuzie, 2009). To mix the methods and integrate findings, I followed an *initiation* mixed methods design in which areas of incongruence and overlap between the two studies were further explored to prompt new exploration, recast interpretations of phenomena, and ask new research questions (Rossman & Wilson, 1985).

Study One

Study One followed the interpretive paradigm, using qualitative methods to inductively explore critical incident narratives regarding workgroup interactions (Strauss & Corbin, 1998). This study examined workgroup level routines for implementing safety and firefighting tasks, specifically the ways that two crews' members engaged in organizing through communicative interactions that implemented safety rules and firefighting tasks. Critical incident narratives (Flanagan, 1954; Gremler, 2004) from two wildland firefighting crews are compared to extract workgroup level differences in interaction patterns relating to local routines and application of safety rules for managing tasks and space.

Critical incidents serve as *texts.* Texts are accounts of previous conversations that bring elements of the organization into ongoing conversations—referred to as *coorientations*--between members (Taylor & Van Every, 2000). Research questions asked: 1) how critical incidents from two crews differed in the ways firefighters interacted (co-oriented) to enact firefighting rules and routines, 2) how critical incidents from the two crews differed in ways firefighters oriented toward the object of material space, 3) how the texts of each crew pointed to different sets of sustained interaction patterns for implementing rules and routines, and 4) how the two crews' texts point to interactions that make reliability visible and facilitate learning. Findings from the first study identified constructs that were examined in the second study, described next.

Study Two

Study Two involved a wide-scale survey assessing workgroup-level safety climate of wildland firefighters. Safety climate refers to the degree to which an organization's practices emphasize safety over production pressures (Zohar & Luria, 2005). Safety climate assessments often measure the following constructs: safety communication (Hofmann & Stetzer, 1996), failure learning behaviors (Carmeli, 2007), work-safety tension (Morrow, et al., 2010), and psychological safety (Edmondson, 1999). Based on Study One, I included additional measures to capture crew staffing patterns and work styles. Hypotheses test and model relationships among variables to determine how crew configurations and work styles combined to

influence learning behaviors, member comfort with communicating safety concerns, and the value and acceptance of communication and learning practices.

Dissertation Overview

This dissertation proceeds as follows: Chapters Two and Three contain the qualitative Study One. In Chapter Two, I include a literature review on high reliability organizations, and an explanation of the qualitative methods I used to gather interview data and conduct grounded theory analysis (Charmaz, 2006). In Chapter Three, I present the results of the qualitative study. Next, Chapters Four and Five present the quantitative safety climate survey (Study Two). In Chapter Four, I present a literature review on safety climate followed by a description of the statistical analysis methods used, including structural equation modeling (Kline, 2011). In Chapter Five, I present the quantitative results of the safety climate study. Finally, in Chapter Six, I integrate the findings from the two studies, describing areas for theoretical development. The chapter concludes with discussions of theoretical and practical implications, limitations of the study, and future directions for this research.

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[1] Wildland firefighting organization refers collectively to the combined federal agencies that conduct wildland firefighting, including the US Forest Service, Bureau of Land Management, and National Park Service.

[2] Firefighting resources: Personnel, equipment, services and supplies available, or potentially available, for assignment to incidents. Personnel and equipment are described by kind and type, e.g., ground, water, air, etc., and may be used in tactical, support or overhead capacities at an incident (USFS, 2008).

[3] Blowup: Sudden increase in fireline intensity or rate of spread of a fire sufficient to preclude direct control or to upset existing suppression plans. Often accompanied by violent convection and may have other characteristics of a fire storm (USFS, 2008).
[4] Incident management team: The incident commander and appropriate general and command staff personnel assigned to an incident (USFS, 2008).
[5] Red Card: Fire qualification card issued to fire rated persons showing their training needs and their qualifications to fill specified fire suppression and support positions in a large fire suppression or incident organization (USFS, 2008).
[6] A Pulaski is a combination chopping and trenching tool widely used in fireline construction, which combines a single-bitted axe blade with a narrow adze-like trenching blade fitted to a straight handle (USFS, 2008).
[7] Fire Line: A linear fire barrier that is scraped or dug to mineral soil (USFS, 2008).
[8] Mop-up: Extinguishing or removing burning material near control lines, felling snags, and trenching logs to prevent rolling after an area has burned, to make a fire safe, or to reduce residual smoke (USFS, 2008).
[9] Cold trailing: A method of controlling a partly dead fire edge by carefully inspecting and feeling with the hand for heat to detect any fire, digging out every live spot, and trenching any live edge (USFS, 2008).

Sustained Line Production Rates of 20-Person Crews for Construction, Burnout, and Holding in Chains/Hour

Fire Behavior Fuel Model		Specific Conditions	Crew Type	
			Type I	Type II
1	Short Grass	Grass Tundra	30 9	18 5
2	Open Timber/ Grass Understory	All	24	16
3	Tall Grass	All	5	3
4	Chaparral	Chaparral High Pocosin	5 4	3 2
5	Brush	All	6	4
6	Dormant Brush/ Hardwood Slash	Black Spruce Others	7 6	5 4
7	Southern Rough	All	4	2
8	Closed Timber Litter	Conifers	7 40	5 24
9	Hardwood Litter	Conifers Hardwoods	28 40	16 24
10	Timber (Litter & Understory)	All	6	4
11	Logging Slash, Light	All	15	9
12	Logging Slash, Medium	All	7	4
13	Logging Slash, Heavy	All	5	3

NOTE: Allowances have been made in production rates for rest periods and cumulative fatigue.

Figure 1. Fireline Production Rates for Type 1 versus Type 2 Wildland Firefighting Crews (NWCG, 2004, p. A-30).

CHAPTER 2

Study One Literature Review and Methods

A Communication Approach to High Reliability

High reliability organizations (HROs) are those that are not able to experiment with trial-and-error learning but must function for long periods of time without catastrophic errors (Rochlin, 1993; Weick, 1987). When accidents do happen, they are thoroughly investigated to extract all possible lessons. These lessons become *centralized* knowledge that is then fed back into the organization's system as revised safety rules or procedures, or focal stories (Weick, 1987). Even though much attention is given to failures and learning from them, one area unexplored in HRO research is how organizational routines, rules and material space are brought into conversation between members. Karl Weick, whose body of research centers on the mechanisms driving organization (as a verb) applied his organizing insights to the HRO context. Central to Weick's work is the idea that organization is an interactive process that is grounded in action, meaning that the organization emerges through action and interaction. From his view, reliability is more- or less- possible depending on how an HRO *organizes.* Focal levels of analysis for much of Weick's work include the organization and individual levels: how *organizations* function as systems of interconnected parts, and attention to ways that an *individual's* noticing of cues and information exchange contributes to reliability.

A communication lens also investigates how an organization emerges through action and interaction. A communication constitutes organization (CCO) perspective

(Taylor & Van Every, 2000, 2011) holds that communicative interactions are the central process by which organizations emerge. A communicative approach to organizational action involves investigating how the organization and the individual are connected through the process of members sharing actions and attributing their actions to the organization (Bencherki & Cooren, 2001). This perspective acknowledges that organizational elements such as routines enter into members' conversations--sometimes directly as the object of interaction, sometimes indirectly alluded to or implied. It is through interactions that organizational elements are brought into conversation, interpreted and acted out. Examining the materiality of space is also a growing area in this perspective (Ashcraft, Kuhn, & Cooren, 2009). Ashcraft et al. propose that the ways organization members deal with sites and spaces are embedded in members' local actions. Thus, attention should be paid to the workgroup context as the important local level where the organization is translated for members and where the forces of socialization and membership are the strongest (Corradi, Gherardi, & Verzelloni, 2010; Moreland & Levine, 2001). From a communicative view, focal levels of analysis include the interaction and workgroup levels.

Applied to high reliability organizations, a communication perspective offers a way to unpack how HRO safety rules and routines are brought into conversation, connecting local action with the organization's structures or directives (Ashcraft, et al., 2009). The core mechanism of CCO is the text/conversation dialectic in which past instantiations of the organization, *text,* that occur through interactions are

referenced in present interactions, *conversation* (Robichaud, Giroux, & Taylor, 2004). Ongoing interactions that reference the organization develop sustained interaction patterns where knowledge becomes *textualized*. As *text*, knowledge is grounded in practices such as *ongoing* interactions involved in problem solving rather than individual instantiations (Ashcraft et al., 2009). Ashcraft et al. argue that turning empirical attention toward practices brings into view how a workgroup shapes what is accepted as appropriate and normative ways of accomplishing work. They argue that in order to locate constitutive communication, a *process* must be under investigation. For example, one process germane to HROs is how rules and routines are used differently in HRO workgroups, or how workgroups perpetuate or privilege certain actions in conducting standard tasks. Therefore, if *reliability* is conceptualized as *consistent* types of actions and *consistent* uses of rules and routines across the organization, then it is important to know whether and how workgroups within the same HRO in their characteristic interaction patterns. If there is variation across the organization in workgroup-level uses of rules and routines, what implications for high reliability emerge both practically and theoretically?

To address these issues, this study examines how communication is the nexus where organization is continually established, resisted and changed. According to Bencherki and Cooren (2011), a communication constitutes organization (CCO) lens does not assume that the organization already exists, but instead examines the explicit link between the organization and individuals-through communicative interactions-and how those interactions generate practices that are constitutive of the organization.

CCO assumes that materiality (e.g., of space, objects and bodies) plays a direct role in constitutive interactions and provides a framework to unpack how sustained practices develop through the shared actions of organization members. A constitutive lens allows us to see how language defines organizational realities as members interact and negotiate meaning. Through language, relationships (to each other and in relation to work) are defined, communicatively acted out, and sustained interaction routines develop (Taylor & Van Every, 2000).

To unpack how HROs are constituted, this study compares the communicative interactions of two HRO workgroups in which members reference rules and routines. It also examines how these interactions contribute to processes of organizing in HROs. I first provide a review of the high reliability organization literature. This review highlights the theoretical perspectives encompassing much of this work. I describe how prominent HRO perspectives (e.g., cognitive, system-based traditions) inform the levels of analysis investigated and drive the types of research questions that are asked. Next, I discuss the absence of work that investigates rules, routines and material space from the HRO literature. I then review how CCO studies have incorporated organizational elements and spatial materiality. Finally, I propose a study addressing how organizational rules and routines and material space enter into HRO member conversations at the interaction and workgroup levels of analysis.

To illustrate the importance of this study, I analyze critical incident narratives from two comparable wildland firefighting crews. Members' narratives recall communicative interactions in which they negotiated with other firefighters regarding

the use of organizational rules and routines, and their orientation toward material space in their firefighting tasks. Implications for high reliability and communication theory, in addition to practical implications for wildland firefighters, will be discussed.

High Reliability Organizations: Core Questions and Analytical Foci of Extant Research

According to Rochlin (1993), high reliability organizations (HROs) are those whose activities are complex, often requiring members to manage significant hazards on a regular basis. They are a unique type of organization because they tend to go long periods of time without accidents in environments rich with potential error. An inability to experiment with trial and error learning characterizes HROs; this amplifies the importance of accidents as opportunities for organizational learning (Weick, 1987). When accidents do happen, these organizations conduct thorough investigations to discover "what went wrong" in order to uncover problematic trajectories of action. A few examples of these organizations include aircraft carriers (Roberts, Rousseau & LaPorte, 1994; Weick & Roberts, 1993), wildland firefighters (Barton & Sutcliffe, 2009; Weick, 1993) and municipal firefighters (Myers, 2005; Myers & McPhee, 2006).

One reason that HROs are a rich context for study is that the reliable outcomes defining these organizations often are invisible. As Weick (1987) points out, "Reliability is … invisible in the sense that reliable outcomes are constant, which means there is nothing to pay attention to. Operators see nothing and…presume that

nothing is happening. If nothing is happening and if they continue to act the way they have been, nothing will continue to happen" (p. 118). This is problematic because a workgroup may develop a routine for dealing with a task, but their method may not account for certain hazards simply because they are unknown and unseen. Therefore, a practice may work under most circumstances—and become taken for granted and unquestioned—but given a slight change in circumstances the practice may bring members in contact with a previously unknown hazard. A second reason that HROs are a rich context is that members face ambiguous circumstances. Environments are ambiguous because there are numerous cues and inputs to prioritize. In some cases, as with wildland firefighting, the environment is always different (e.g., different location, terrain, fuel type, etc.). Given this situational ambiguity, members are tasked with deciding what actions to take in response to their environments (Rochlin, 1993; Weick, 2005). Dealing with situational ambiguity means that members are not easily able to know whether they understand-or even see a problem. They may not know whether the problem is within their jurisdiction to deal with, and they may not know if they have appropriate or adequate experience to address the problem (Alvesson, 2001).

Existing HRO research and theory is rooted in cognitive and management perspectives whose central concerns involve determining how members come to understand the environments they must respond to or their complex organizations. One prominent vein of cognitive-based research takes the organization as the unit of analysis and asks how systems of interconnected units and people operate together

based on their cognitive representations. A second vein examines the individual level of analysis asking how members read the environment to develop cognitive representations it. These two perspectives are discussed next.

Organization-Level View of Reliability

An organization-level view of reliability is concerned with the ways that interlocked actions generate reliably error-free outcomes for the system. Because high reliability organizations are characterized by the complexity of their numerous and interdependent tasks (Rochlin, 1993), HRO studies emphasize findings and concepts related to the organization's system-like characteristics, including interrelated sub-systems and the embeddedness of small units inside larger units (Grabowski & Roberts, 1997, Roberts, Stout & Halphen, 1994; Weick & Roberts, 1993). In this case, knowledge that contributes to reliability is in the cognitive schemas of systems and interrelated parts that members have.

From the organization-level view, reliability is conceptualized in terms of cognitive constructs as follows: First, members develop a broad understanding of the HRO's objectives, as well as detailed understandings of how interrelated subsystems function to accomplish those objectives (Perrow, 1984). Second, keeping these mental maps in mind, members act flexibly and somewhat autonomously because their schemas provide scripts for how member and unit actions contribute to the overall interrelated whole (Grabowski & Roberts, 1997, Weick & Roberts, 1993). Third, schemas and scripts decentralize authority enabling organization members at any level to adjust their actions in the moment to adapt to unexpected events (Perrow,

1984).

This cognitive process is the basis of concepts such as collective mind and heedful interrelating. Weick and Roberts (1993) discuss these ideas in the context of an aircraft carrier flight deck. Collective mind refers to individuals acting with the organization's broader goals in mind. *Heedfulness* refers to the degree to which individuals act carefully and mindfully. Weick and Roberts view heedful interrelating as a process that enacts the collective understanding of the organizational system through three processes: 1) Contributing refers to individual's actions toward the overall goal; 2) Representing refers to the distributed collection of similar understandings of the goal by members throughout the system; and 3) Subordinating refers to the ongoing stream of individual activities that enact the system as a whole, meaning that individuals understand that their actions are necessary but of secondary importance relative to the system's goal.

The next section reviews individual-level views of reliability followed by a communication-based critique of both sets of these ideas.

Individual-Level View of Reliability

HRO operating environments consist of complex, ambiguous circumstances in which there are poor understandings about the nature of the problem and cause-effect relationships. There is a lack of clarity about the kinds of information that are problematic or helpful, and there are multiple conflicting interpretations of the data at hand (Alvesson, 2001; Sutcliffe & Weick, 2008; Weick, 2001). From this view, reliability is rooted in *requisite variety*-- the idea that the complexity of organizing

processes must equal the complexity of environmental changes and turbulence the organization is tasked with responding to (Weick, 1987). A nuanced understanding sharpens members' detection of problematic cues. The development of individual-level knowledge is emphasized and training focuses on providing experience through repeated exposure and expanding knowledge so that members can add as many possible ambiguous situations to their repertoire of responses. As in the organization-level view of reliability, knowledge is conceptualized as a cognitive entity that members collect and share (Ashcraft, et al., 2009; Blackler, 1995). Individual-level mechanisms for high reliability unfold in three primary ways.

First, large-scale disasters such as Bhopal (Shrivastava, 1987), Three Mile Island (Perrow 1981) and the Mann Gulch fatal burn-over of wildland firefighters (Weick, 1993) are extensively reviewed to extract the lessons that current and future members can retain. Detailed investigations into large-scale incidents become part of the organization's history and narrative and comprise a body of shared knowledge that accumulates from experiences and learning (Bierly & Spender, 1995; Klein, Bigley & Roberts, 1995; Roberts & Bea, 2001; Weick, 1987). This knowledge becomes textualized in the form of safety rules or revised procedures (Zeigler, 2007) and passed from generation to generation of members through storytelling and training (Weick, 1987). Organizational knowledge is thought to trickle down to the individual by way of policies and rules designed to inform *individual* actions. For example, according to Zeigler (2007) a list of safety rules guides wildland firefighters' actions. It is a set of rules that was developed in response to common

factors that have contributed to firefighter fatalities. The list has been used for several decades and the meaning of it has shifted over time. In recent decades discourses around the list promotes an *individual ethic* meaning that firefighters are expected to take responsibility for their individual safety by internalizing the rules on the list. Hence, reliability becomes an outcome of individual actions that are free of "mistakes."

Second, avoiding individual "mistakes" has prompted a line of research on *safety cultures* and *climates*-the way that members of organizations' sub-cultures promote and reward safe actions (Zohar, 1980; Zohar & Luria, 2005). While the term *climate* conjures the idea of the social collective, the ultimate goal of a safety climate is for individuals to report their errors to the workgroup providing as much information as possible about the causes of mistakes in order to prevent future mistakes. When making mistakes as a result of "right" actions, members are absolved of blame. This is thought to instill trust among members and promote sharing (Reason, 2000). Talking openly about mistakes alerts members to novel situations that should be avoided. Again, avoidance of individual mistakes is the mechanism for reliability.

Third, the ongoing process of sensemaking occurs as members share insights and observations in-the-moment as they co-construct explanations of what they are seeing in their environments. This is evident in Weick, Sutcliffe and Obstfeld's (1999) discussion between neonatal intensive care unit (NICU) care providers diagnosing the condition of an infant patient. From this ongoing sensemaking view,

Weick points to the phrase "how do I know what I know until I see what I say." Thus, the idea is that *situations* (e.g., diagnoses, environments, etc.) are *talked* into existence. The ongoing sensemaking approach has been studied extensively in both HRO and non-HRO contexts (Barton & Sutcliffe, 2009; Blatt et al., 2006; Gephart, 1993; Maitlis, 2005; Murphy, 2001). Several of these studies focus on factors that enable and constrain free exchange of information. The question that this type of study answers is how ongoing talk *defines* a situation (such as a diagnosis or emerging safety issue), but it does not unpack how the interaction enacts the process of *organization*. That is, it does not unpack how interactions between members instantiate communication in such ways that their ongoing talk orients them in relation to one another, orients each communicator to the task, or structures relations of authority. The next section proposes a communicative view for HROs.

Toward a Communication View of High Reliability Organizations

To review so far, theoretical perspectives shape how communication is conceptualized and inform what kinds of questions are asked to address possible mechanisms for high reliability. The prominent cognitive approaches conceptualize communication as a means to help members align their cognitive models about the organization (e.g., cause maps of the system's interrelated parts). At the individual level of analysis, a cognitive approach asks how members talk *situations* or *environments* into existence. Communicators develop a representation of the environment or a situation through talk, but again communication functions as a means for individuals to align their cognitive representations and exchange

information.

Also important is how action is conceptualized from a cognitive view. What Weick means when he says that sensemaking is "grounded in action" is illustrated the question "how do I know what I know until I see what I say?" From this view, the question is *how do members make sense through action*? Asked in this way, the question highlights individual-level insights and learning.

In contrast to a cognitive lens, a communication constitutes organization (CCO) approach to high reliability organizations asks different questions at different levels of analysis. First, instead of asking how organization members talk *situations* into existence, a CCO perspective asks how members talk *action* into existence. There are subtle but important differences between these questions. Examining the *individual* unit of analysis, a cognitive perspective investigates member interpretations of what they see; this generates a representation of the environment that is housed in the mind. For CCO, the *communicative interaction* is the unit of analysis as members talk into existence *which actions* to take together. Further, CCO takes into account that choices for action reference organizational elements such as rules or routines; hence the organization is made present through interactions that interpret the organization while also informing the action.

Second, a CCO approach to high reliability is grounded in action. A cognitive approach asks *how [individual] members make sense through action*, thus generating a cognitive representation of their surroundings that allows them to notice and bracket cues and gain understandings of cause/effect relationships. In contrast, a

CCO approach assumes that action is social and practical. Therefore, a communicative perspective asks *in what ways do members enact appropriate actions?* Here, *appropriate action* is not purely based on what is going on in the environment, but strongly subject to the social pressures at the workgroup level that shape what is accepted as normative and appropriate action. Further, Weick's (1987) initial notion of *enactment* held that action makes environments sensible. Implicit in this idea is that action occurs in material *space* and action makes space sensible. However, material space remains largely unpacked in the HRO literature.

Further, the workgroup level of analysis is focal in communication research. Workgroups are the intersection between individual behavior and the organization's structure (Poole, 1998; Seibold, 1998). This level provides most of the socialization and translates the organization for members (Kramer, 2009; Moreland & Levine, 2001; Myers & McPhee, 2006). Amin and Roberts (2008) argue that it is important to consider social conditions involved in helping members gain competence. In many HROs, the workgroup is also the organizational entity that directly interfaces with the material environment (e.g., a *crew* of wildland firefighters responds to a fire) while drawing from organizational features such as rules and routines. I argue that HRO workgroups are the level at which a particular HRO occupation operates as a coherent unit of action and intention (Taylor, 2009). HRO members' workgroup relationships are highly interdependent for both learning and for functioning safely (Myers & McPhee, 2006). Workgroups are the social communities acting as the source and medium for constructing and inculcating social and working practices

(Corradi, et al., 2010). Thus, if the *text* can be located in action and communicative interaction, then conversations about the workgroup's rules, routines and space can reveal practical actions that become inculcated and perpetuated.

The next section builds out from these critiques, proposing how a CCO approach incorporates organizational rules, routines and material space in analyses of communicative interactions. Applications to high reliability organizations are presented.

Function of Rules and Routines in High Reliability Organizations

Conspicuously absent from the HRO literature is discussion of how rules or routines are brought into conversation between members. Research on organizational routines partially addresses some of the above critiques of HRO work: Routines research is grounded in observing member's actions; it tracks routine change and offers explanations for why (Pentland & Feldman, 2005), and describes how routines connect communicators with one another (Feldman & Rafaeli, 2002). The following section briefly describes rules and routines and why they should be acknowledged in HRO research and theory.

Rules and routines. Rules are defined as "conditional or unconditional patterns of thought or behavior which can be adopted either consciously or unconsciously by agents. Generally rules have the form: in circumstance X, do Y" (Lazaric, 2000, p. 161). Rules tend to be broad so that they can apply to a wide variety of circumstances. According to March (1997) "Rules are ambiguous; more than one rule may apply in a particular situation; and the behavior required by the rule may be shaped through

interpretation" (p. 20). Therefore rules are abstract instructions that organization members must translate into action. Routines, on the other hand, are patterns of action (Becker, 2004; Pendland & Feldman, 2005). Routines are embedded in social contexts and address organizational goals and issues at the local, interactional level (Pentland & Feldman, 2005). Rules are considered to be complementary to the notion of routines because rules are abstract notions of an organization's directives, while routines consist of the patterns of action that enact rules (Lazaric, 2000). Becker (2004) argues that organizational knowledge is embedded in routines; that is, knowledge persists over time because it becomes instantiated in local patterns of action that enact and reenact routines. Rules and routines are germane to high reliability organizations for two important reasons: First, rules are abstract mandates from an organization that embed knowledge (in HROs, safety knowledge learned from accidents). Second, routines are the local-level patterns of action that translate rules into action. This section describes how research on routines is, like HROs, grounded in an action-based perspective.

Pentland and Feldman (2005) problematize routines as incorporating three very different features: artifact, performative and ostensive. The artifact aspect refers to the organization's written directives outlining the routine (e.g., standard operating procedure manuals, forms or checklists). The performative aspect refers to observed patterns of action as members conduct the routine. This includes who performs what, timing of actions, reasoning behind actions, and where the actions took place. The ostensive aspect refers to the abstract, overall idea behind the routine. Here, the steps

of the routine are summarized, and different accounts of the routine are compared in order to reveal various perspectives from which organization members approach the routine. Each of these three aspects, according to Pentland and Feldman (2005) leaves open room for interpretation because unpredictable contexts and conditions mean that routines can never be fully standardized nor can they determine actions.

Routines become problematic when there are inconsistencies among the ostensive, artifact and performance aspects (Pendland & Feldman, 2005). For example, a policy (artifact aspect) designed by managers may shape how a routine is structured on paper, but the implementation of the routine (performative aspect) might play out very differently due to practical constraints. This type of inconsistency may play out in HROs as follows: HROs that rely on investigations of catastrophes to alter their operating procedures and routines to prevent accidents may provide workers with directives that are impossible to follow in consistent ways time and again given the nature of the spaces and conditions in which they operate. This becomes a major concern if "reliability" is thought to be a product of consistent patterns of action. Thus, because practical circumstances may inhibit exact repeats of performances, Pentland and Feldman point to the importance of interpretations and flexibility in implementing routines. As such, they view routines as "effortful accomplishments" rather than mindless action. I will argue that the notion of an "effortful accomplishment" can be unpacked more if we set the routine within a workgroup context and in interactive conversation. First, however, the relationship between routines and interaction is addressed.

Routines and interaction. Feldman and Rafaeli (2002) advance a network-inspired view of routines as enabling connections among members. Their idea is that through the course of enacting the steps of a routine, an individual actor may encounter numerous other organizational actors that play a role in the completion of that routine. They argue these connections enable communication that develops shared understandings for performing the routine, as well as shared understandings about the organization (e.g., what the organization does, who holds what roles, the array of power relationships, etc.). Feldman and Rafaeli argue that routines connect people, but their discussion does not unpack how interactions between connected members bring the routine into conversation where it can be interpreted, adopted or perpetuated. Further, routines research focuses on *individuals'* uses and adaptations of routines. This work also centers on the routine itself, its sequence of actions and ways the sequence changes; however, it not specifically address the intertwining of action and interaction that shape and inculcate its interpretation. A CCO approach, on the other hand, does examine how routines are brought into communicative interactions between members and is discussed next.

CCO and routines. CCO studies examine how the organization is made present in and through communicative interactions around organizational elements such as routines and rules. One key study explores how an organizational text defined the relationships among communicators, while the enactment of their relationships simultaneously instantiated the organization at multiple levels of embeddedness. Faure, Brummans, Giroux, and Taylor's (2010) study examined interactions in which

communicators revised an accounting budget. The budget was a *text* that defined relationships between the communicators; the organization was brought into being as they evoked accounting rules. This study examined interactions among three organizational representatives (a triad) who each played a different role in constructing the budget, and demonstrated how the budget as a *text* oriented these representatives in relation to one another. The jurisdictional authority each representative had over his respective aspect of the budget influenced how he oriented toward the other two organization members. Faure et al. also examined how interactions and relationships were embedded in various levels of organization through the process of co-constructing their budget. Specifically, some conversations around the budget differentiated among the three representatives as they held one another accountable to their immediate triad. In other instances the triad was embedded in a larger organization; thus, the three were united as a coherent organizational unit during conversations around presenting the budget to a higher authority in the organization.

Faure et al.'s (2010) study demonstrates how texts enter into member conversations, structuring interactions while at the same time enabling and constraining how the texts are interpreted and used. The distinct ways that members performed the three roles related to the accounting budget created multiple levels of organization. Applied to high reliability organizations, this study provides a basis for unpacking how safety rules and routines serve to structure interactions between and among organization members through defining their relationships to one another and

delineating authority. Further, a practical issue for a large HRO, such as wildland firefighting, with a central set of safety rules is that members might encounter situations of having to negotiate conflicting interpretations and enactments of safety rules and routines. Therefore it is important to examine conversations in which members interpret how the rules and routines should be acted out, because these conversations and the resulting actions constitute the organization.

In some organizations, safety rules and routines specifically address issues of space. For example, wildland firefighter safety rules specifically address where firefighters should and should not be located in relation to the fire (IRPG, 2011). The next section discusses how rules and routines related space are important in HROs.

Space in High Reliability Organizations

Physical space is a key component defining many HROs such as wildland firefighters (Barton & Sutcliffe, 2009; Weick, 1993; Zeigler, 2007), municipal firefighters (Myers, 2005; Myers & McPhee, 2006), and aircraft carrier flight decks (Weick & Roberts, 1993). While researchers acknowledge the environments in which HROs operate, they often do not address how HRO members talk about the spaces where their work occurs, or how members negotiate space in light of rules or routines.

Research and theory on space in organizations (in general) is vast. One review, rooted in the management field (Taylor & Spicer, 2007) divided the literature into three categories: 1) The majority of studies conceptualize space as objective distance, which examines, among other things, workplace layout and physical barriers between employees and resources. 2) Numerous studies examine how power relations are

materialized in space. These studies tend to use Marxist or Foucaultian approaches to analyze how spaces are arranged for the benefit of capitalism or disciplinary surveillance, respectively. For example, research might explore how shop floors (and entire company towns) are arranged to cluster workers in ways that enable the greatest degree of management control. 3) A growing body of work in recent years includes studies that examine space as lived experience. These studies examine how humans experience is aligned in space through sensory and cultural filters that ascribe meaning to lived experiences. This third category of studies parallels CCO work that focuses on the interplay between the material and the social aspects of organizational life.

With the interplay between physical experience and meaning in mind, Ashcraft et al. (2009) divided the space/site work into two succinct categories: studies that privilege the ideational elements, and studies that privilege the materiality of space. *Ideational* aspects include symbolic understandings of organizational culture, including how human elements such as language, cognition, metaphors, desires and norms work to produce and reproduce understandings of organizational actions and experiences. *Materiality* refers to the technical, concrete and physical factors of organizational sites (also objects and bodies). They argue that a CCO perspective on space must simultaneously consider both material and ideal aspects of space in processes of organization. Intertwining the material and ideational elements of space means that space is recognized as a physical, material reality but that communicative action and organizational norms for how members deal with space involve symbolic

aspects, too, such as socially constructed norms for valued or appropriate action in space.

A recent theoretical paper begins to demonstrate this material/ideational simultaneity. Dale (2005) investigated the intertwining of ideational and material aspects of space. Her essay is groundbreaking because it unpacks how *social* structures and processes are mutually enactive with *spatial* structures and processes. Prompting this research is a shift in organizational structures from a vertical, hierarchical form of control to horizontal, concertive forms (Barker, 1993) of control in which members are subject to surveillance by peers. Dale argues that the materiality of spaces is important because we experience home and work spaces on a routine basis. As a result, we take for granted how relations between organizational actors are arranged in that space to cluster some people together for ease of surveillance, or to separate the powerful from the less powerful, a Foucaultian view. Also, spaces are imbued with symbols of status (e.g., plush office furniture) or resistance (e.g., photos of family, cynical cartoons, etc.). Space functions in organizational control because space arrangements direct traffic flow, and by extension communication patterns among various organizational units and actors. Dale emphasizes how space structures power relationships, enabling some interactions while blocking others. While Dale focuses heavily on the production of power relationships, the way she unpacked the intertwining of ideational and material space can be applied to other concepts.

To explore space further, and following Dale (2005), Ashcraft, et al., (2009)

suggest that a constitutive lens could focus on knowledge and knowing as it relates to ways that material realities of space, organizational elements (e.g., rules, routines, texts) and local norms for problem solving are interwoven in shared action. This view is pertinent to HROs like wildland firefighting that depend on developing or adapting rules and routines based on catastrophes. Knowledge for these HROs, as previously mentioned, is conceptualized from a cognitive perspective and the organization trains members extensively for the purpose of transferring knowledge (conceived of as a cognitive entity) to its members, considering communication to be an unproblematic information transfer. Ashcraft et al. suggest shifting toward a practice-based focus meaning that knowledge is embedded in ongoing activities. Adding to this, Dale (2005) points to the importance of asking how organizational structures (e.g., vertical or horizontal) inform the normative ways that space is dealt with. For instance, does a hierarchical organization have different ways of managing space (e.g., in implementing rules and routines) than does a concertive control type of structure? Thus, the issue becomes how communication serves to connect local action with the organization's structures or directives. It is through communicative interaction that sustained patterns of action develop for dealing with space.

Theoretical Model and Research Questions

Previous sections have introduced how a CCO perspective can be applied to HROs for the purpose of shifting the focus away from the cognitive and toward a communicative view that is rooted in action and interaction. This section provides a more detailed description of the CCO perspective. Key CCO concepts are highlighted,

and a theoretical model and research question are proposed.

Recall from the beginning of this chapter that the conversation/text dialectic is the central constitutive process. *Conversation* is the communication process; enduring *texts* created in previous conversations are referred back to and hold the memory traces of the organization (Taylor & Van Every, 2000). The conversation process is the nexus where texts are created, maintained, contested and changed, so the organization is not a static entity. (Putnam & Nicotera, 2009; Robichaud, Giroux & Taylor, 2004; Taylor & Van Every, 2000).

CCO and Stories

Stories are representations of ways that people have processed their actions. A *narrative mode of reasoning* is the idea that we organize and understand our lived human experiences in narrative forms such as stories, reasons we did or did not do something, excuses and myths (Bruner, 1991; Taylor & Van Every 2000). Taylor and Van Every (2000) describe that the narrative mode of reasoning operates simultaneously at the individual level and at social levels (e.g., workgroup, organizational, etc.). We have deeply ingrained habits for thinking and talking. These acquired ways of talking are referred to as the *surface of emergence* of an organization. By "surface of emergence," Taylor and Van Every (2000) mean that narrative is a central process in constituting an organization. Narrative reflects the interplay between *conversation* and *text*. When members reference aspects of the organization in their talk, the talk links the social to the individual: "Through its translation into a narrative text, the organization is both naturalized and socialized: it

is made an object [text] like any other and legitimated socially [through conversation]" (Taylor & Van Every, 2000, p. 45). Further, what people know always comes from a point-of-view and cannot be understood without also taking into account the ways other people (e.g., colleagues, friends, etc.) participate in the narratives.

CCO provides a framework for exploring the two primary theoretical issues in this chapter. First, drawing from the concept of *coorientation*, a CCO lens helps to examine how organizational rules, routines and material realities enter into accounts of interactions. Second, a CCO perspective is useful for unpacking how the accumulation of practical actions creates a *text*, a coherent sense of the organization at the workgroup level. In order to locate how communicative interactions constitute organization, there are two levels of analysis at work in this study. The workgroup level of analysis is where norms and practices are salient and where the organizational *text* forms from accumulations of coorientations over time. The interaction level of analysis examines coorientations between workgroup members that are rooted in practical action. The next section introduces the organizational context of the study for the purpose of situating the subsequent theoretical model and research questions.

Co-orientation: Action, Interaction and Spatial Materiality

Co-orientation is the minimal communication unit, a triad, linking 2 communicators (A and B) with a common object (X) (Taylor, 2009, p. 155). Coorientations serve as the *conversation* in the conversation/text dialectic. Montreal CCO takes this ABX triad to be the basic *unit of analysis* for explaining

communication relationships and how more complex configurations become structured over time through members' regular interactions. In the ABX triad, A and B hold complementary relationships relative to each other that are explained by their respective orientations toward object X (Taylor & Van Every, 2000).

The object X of interaction often emerges in the joint activities members engage in (Taylor & Robichaud, 2004). According to Taylor and Robichaud, the object can "anchor co-orientational relationships that link organizational agents" (p. 401). Actors first align themselves individually toward the object of conversation (e.g., a joint activity or task); these individual alignments represent AX and BX subject-to-object relationships. The nature of the object emerges when A and B align their organizational perspectives, knowledge bases and intentions toward the task at hand. Based on how A and B align their different perspectives, different issues may arise as the object is negotiated and established through interaction; these interactions establish the coorientational relationship between agents. The object of interaction is not specifically physical or spatial. Instead, the object emerges as a common concern for A and B due to their respective memberships in their organizational communities, and given constraints they negotiate as they implement tasks.

Interaction Level of Analysis. Tsoukas (forthcoming) proposes that practical actions yield a narrative connecting events, spaces, people, and other elements of experience. Stories are the verbalized interpretations of the decisions and actions that organization members make, and are the remembered system of order and action that was developed (Weick, 1995; Weick & Browning, 1986). Stories are *representations*

of ways people have processed their actions and their coorienting.

The unit of analysis for this study include the interactive coorientations that arise as texts in critical incident stories (Flanagan, 1954; Gremler, 2004). A *critical incident* is an account of human activity that was observed by the participant and complete enough to enable the researcher to make inferences about the participants involved in the actions (Bitner, Booms & Tetreault, 1990; Gremler, 2004). Critical incident accounts are gathered in various ways, but the typical approach is to ask a participant to tell a story about an experience he or she has had (Gremler, 2004). Hence, critical incidents are *texts* of previous coorientations. These critical incident stories told by (A) about interactions between individuals (A & B) regarding objects (X). In this case, the objects (X) that people are coorienting about include firefighting activities in general, but of interest is how rules, routines and material space are enacted in the coorientations. These critical incidents function as texts when the stories illustrate a workgroup-level precedent for how to normatively enact rules, routines or manage space.

Routines and rules. As previously discussed, a CCO perspective examines how the organization is made present in and through communicative interactions around organizational elements like routines and rules. The interaction level of analysis focuses in on the ways that HRO members bring safety rules and routines into conversation as objects of interactions, or texts, that members draw on in the interaction. When members debate what the rule is and whether it applies, it is an object of interaction. When previous conversations and instantiations of a rule are

drawn upon later, the conversation becomes a text. Thus, the constitutive question is how member interactions point to sustained practices for enacting the rules and routines that make the organization present at multiple embedded levels. On this basis the first research question is as follows:

> **RQ1a**: What are the critical incidents that firefighters employ to enact rules and routines as they co-orient their activities?
>
> **RQ1b**: How do the two crews compare in the ways that they use these rules and routines to take action in managing fires?

Space. Ashcraft et al. (2009) proposed that the intersection of actions and communicative interactions captures the ideal and the material as they interweave in time and across space. Some research on organizational sites focuses on the *built* environment acting as an anchor for social actions (Shatzki, 1996). For HROs, like wildland firefighting, that are constantly encountering different terrain and constantly changing conditions, this emphasis could be reversed. Thus, interactions would act as an anchor for actions taken within the material space. Social practices may differ by workgroup meaning one workgroup's normative ways of acting in space and interacting about space might be entirely different from another workgroup's. On this basis, the second research question is proposed:

> **RQ2:** How do critical incidents from the two crews compare in the ways that communicators orient toward material space while implementing the organization's rules and routines?

Text: Cumulative Coorientations and the Development of Sustained Practices

According to Taylor and Robichaud (2004), a text communicates a workgroup's typical enactments of routines and rules and serves as a basis for future enactments. Texts reflect what was said, provide a record of past conversations, and are enacted in future conversations. Texts are interpretations of the world that are collectively negotiated through conversation; conversation "turn[s] circumstances into a situation that is comprehensible and that serves as a springboard for action" (Taylor & Van Every, 2000, p. 40). In this study critical incidents serve as texts when they illustrate how a crew's members enact rules or routines through reported co-orientations. This study examines how critical incidents function as texts in wildland firefighting. Wildland firefighting knowledge is both conceptual and physical. They must apply conceptual understandings of rules and routines to constantly changing physical realities. The social environment and physical realities play a central role in what constitutes their knowledge. This combination of social factors and material realities are embedded in firefighters' stories when these stories become part of the social milieu of the workgroup. These enactments become abstracted and removed from situated interactions and become the basis of future conversations around how to perform firefighter tasks (Putnam, forthcoming; Robichaud, Giroux & Taylor, 2004). Organization emerges through ongoing conversations in which texts are invoked. Text shapes conversation, but conversation can recursively reify or change the text. In an HRO, organizational knowledge can be thought to be stored in the workgroup's textual reference, meaning that knowledge is embedded in the workgroup's sustained

routines.

RQ3: What types of texts do the two crews draw on in generating rules and routines?

Communication and High Reliability

Reliable outcomes are invisible. Members manage situational ambiguity. And a central part of HRO workgroups is to incorporate lessons learned from previous mistakes, whether they are large-scale catastrophes or small mistakes with idiosyncratic knowledge. Thus, from a communication perspective, using coorientation and text as the basis for discussion, the next issue is whether the sustained practices the workgroups use actually address the problems of explaining how reliability occurs (invisibility, situational ambiguity, lessons from previous failures). On this basis the final research question is posed:

RQ4: How do the two crews' texts point to coorientations or interactions for making consistency visible?

Methods

My Role as Researcher

I spent eight seasons as a wildland firefighter. The reasons why I chose that line of work related as much to my upbringing as they did to my interest in the work. My father spent a considerable portion of his Forest Service career as a field-going Forest Ranger. As a result, I spent my childhood in rural communities in which the Forest Service was among the few large employers. Growing up, I witnessed my father's personal commitment to his work and to the organization, much like Kaufmann

(1960/2006) described in his study on the Forest Ranger. At my father's suggestion, I began working for the Forest Service the day after my eighteenth birthday. My first job was on a wilderness trail crew that was also trained for wildland firefighting. That season was my entrée to the profession and thereafter I pursued work on crews whose sole purpose was firefighting. By the time I left fire to pursue graduate school, I had spent at least some span of time working in every wildland fire specialty except for smokejumping. I worked on an engine, a type 2 handcrew, a hotshot crew, and my fire career culminated with three seasons in a permanent federal appointment as a mid-level supervisor on a helicopter rappel crew. Gaining experience throughout the organization enabled me to experience firsthand both the dynamic firefighting environment and the complexity of the organizing processes that occur in response to it. These experiences stimulated my interest in studying the organization.

HRO Context: Heli-Rappel Wildland Firefighters

This study examined wildland firefighters' critical incident narratives of times when they had engaged in co-orientations with other firefighters, drawing rules, routines and issues of material space into their interactions. Interviews were conducted with members of two crews of wildland firefighters that specialized in rappelling from helicopters and using the aircraft to manage various missions. Several studies have investigated the wildland firefighting context, but the extant literature related to wildland firefighting, and HROs in general, has not paid much attention to the communicative interactions in which members reference rules, routines or material space during task coordination. Therefore, this study examines

accounts of those types of conversations (the interaction level of analysis). Two comparable crews were chosen for the purpose of comparing the workgroup levels regarding interactions and workgroup *text*.

Participants

I conducted interviews with 27 wildland firefighters from two heli-rappel crews. Interviews were first conducted in late summer 2010 with the West Fork crew. A total of 15 West Fork members were interviewed (see Table 1 for a breakdown): 12 males, 3 females; ages ranged from 26 to 40 (median 32); total number of fire seasons ranged from 4 to 21, half of those interviewed had 10 or more total fire seasons. Four interviewees were in their first season with West Fork, four had spent between nine to 19 seasons on the crew, and the remaining seven ranged from two to six seasons on the crew. Participants included two assistant foremen, three squad leaders, two senior firefighters, seven seasonal members and one apprentice. The 15 participants accounted for nearly all of the members who were present at their home unit base during the two weeks in which the interviews took place; two West Fork members declined to be interviewed.

The West Fork crew typically employs 25 firefighters for the summer. Their base station is located in the USDA Forest Service Intermountain Region, which comprises Nevada, Utah and portions of Wyoming and Idaho. The crew manages two helicopters, which often are assigned to separate fire incidents. The 25 members rotate among three locations throughout the summer: members work with either the first helicopter, the second helicopter, or they are stationed at the base. Members

often are working with different personnel from their crew on each of their two-week rotations, and a large number of the crew members are qualified to take on individual assignments that take them away from the crew to fill various roles on large fire incidents in the nation.

In fall 2010, I conducted interviews with the second crew Manzanita. A total of 12 Manzanita members were interviewed: 11 males, 1 female; ages ranged from 24-34 (median 29); total number of fire season ranged from three to 17, more than half of the interviewees had six or fewer firefighting season. Four firefighters were in their first season with Manzanita, one (the Assistant Foreman) had seven seasons on the crew, and the remaining six had two or three seasons on the crew. Participants included one assistant foreman, two squad leaders, five apprentices and four seasonal members. These 12 participants accounted for the total of Manzanita members available during the two-week interview period, and no members declined an interview.

Manzanita is based out of the USDA Forest Service Pacific Southwest Region (comprised of California). The crew typically employs 20 firefighters and they manage one helicopter. All members work together for the entire season, with the exception of a few of the higher-level supervisors on the crew who are able to take independent assignments.

I gained access to the interviewees through my personal contacts within the organization. During my firefighting years, I became friends with a few West Fork members as a result of working on a handful of fire assignments with them. My point

of contact on the West Fork crew recommended I contact the crew supervisor for Manzanita to ask if the crew would be willing to participate. I did and they accepted.

Interviews

Interviews were conducted on site at each crew's base station. To ensure privacy each interview took place in a private office with the door closed. After gathering information from participants related to demographics and his or her firefighting background, I followed a semi-structured format asking questions related to two broad areas: First, I sought information from each participant about his or her workgroup. I aimed to capture what members felt made their crew unique, and to understand the normative practices of the two crews. Second, I asked participants to talk about a firefighting experience--a *critical incident*—that the participant felt was important in developing his or her firefighting knowledge. Overall, interviews lasted between 30 to 60 minutes were recorded, transcribed and labeled with each participant's pseudonym. Interviews yielded more than 400 pages of transcript.

Critical incidents. The first portion of the interviews ascertained the participants' critical incident stories (Flanagan, 1954; Gremler, 2004). A *critical incident* is an account of human activity that was observed by the participant and complete enough to enable the researcher to make inferences about the participants involved in the actions (Bitner, Booms & Tetreault, 1990; Gremler, 2004). I asked each participant to talk about a memorable fire experience that he or she felt was important for developing his or her expertise as a firefighter. Several participants immediately came up with stories to tell while other members struggled to recall one.

To cue their memories, I further explained that I was interested in experiences such as times when they were surprised by fire activity, took on a position of responsibility or leadership for the first time, experiences when something when wrong, or times when an incident went particularly well. Nearly all of the critical incidents involved rules and routines; participants' stories described debates about how to enact rules, descriptions of typical routines their crew conducts, and instances in which they developed a new or altered understanding of a rule or routine.

Because summer 2010 was a relatively uneventful fire season, many members from each crew did not have what they felt were notable critical incident stories from the current season. However, several members on each crew had worked more than one season on their current crew. Therefore, roughly two thirds of the critical incident stories from each crew provided instances of *coorientations* and clues about *texts* germane to the present research questions, while one third of critical incidents did not offer stories (an exact breakdown is presented under *Analysis*). Critical incident stories aside, all interviews provided valuable data for analyzing crew texts.

Crew routines. The second portion of the interviews covered a variety of topics related to the normative functions of the crew. First, because nearly all critical incidents involved enacting a rule or routine, I asked probing questions about their crew's normative ways of doing so. These questions aimed to capture crew-level differences in their typical ways of approaching firefighting tasks while enacting rules and routines. My next priority was to further unpack how the two crews were similar and different from each other. I asked questions about what members felt

made their crew unique. I also asked them what new members needed to know if they were to be successful members in their current workgroup. These questions address the norms underlying the crew's culture, and prompted them to discuss ways in which new members were socialized, including participants' own stories of performing tasks in the “right” or "wrong" way, ways they struggled to adjust to the crew’s expectations, or ways that their current crew differed from crews on which they had previously worked. To further assess their workgroup-level normative practices and to understand what they thought set their crew apart from other crews in their helitack/heli-rappel specialization, I asked them how they can tell if a crew is a good one or not. This not only assessed what they felt made them different from other crews, but also the extent to which members felt their crew was prestigious and clearly distinct from other crews.

Analysis

There were several goals for the analysis. The first goal was to analyze critical incident stories for instances of coorientations in which organizational rules or routines were mentioned. Second, I examined critical incidents involving space. The third goal was to identify workgroup-texts by examining how critical incidents and crew level norms pointed to sustained practices in the two crews. Finally, based on the findings regarding coorientations and crew texts, I discussed the practical and theoretical implications for high reliability organizations.

First, I read through all of the interviews in their entirety to get a feel for participants' responses and to get an overall idea of broad similarities and differences

between the two crews in both 1) the themes of their critical incident stories, and 2) what members described as being unique and normative about their crews. During this initial review, I marked the transcripts in the margins to identify these elements. I then extracted all of the critical incident stories, grouped them by crew and stored them in one electronic file.

Second, I systematically coded each transcript in its entirety, including the critical incident stories. To develop the initial coding dictionary, I selected two transcripts from each crew. These were interviews with members who had worked on their respective crew for more than one season, and who stood out as descriptive and insightful about their crew and experiences. The purpose for those initial selections was to save time, as I anticipated that the majority of codes might be captured from more- rather than less-descriptive interviews. Once the coding dictionary was developed, I coded all of the West Fork interviews first, followed by all of the Manzanita interviews; order was determined by a coin toss. I elected to code each crew's interviews separately so that I could continue to gain a strong sense of the distinctive feel of each crew. I updated the coding dictionary after each subsequent transcript to reflect new codes that emerged and to refine coding categories. Once West Fork interviews were complete and I began coding Manzanita, the coding dictionary required the addition of several new sub-categories for codes due to crew differences. Likewise, there were several sub-codes from West Fork that did not emerge in the Manzanita transcripts.

I used an open coding procedure (Strauss & Corbin, 1998). This involved

reading through the critical incidents and crew information line by line--sometimes paragraph by paragraph--to label what participants discussed regarding their critical incidents and crew environments. I first mapped their coorientations, followed by the crew texts. When coding was complete, I manually sorted all of the data into separate files-one for each of the 38 sub-codes (described in more detail below).

To identify instances of *coorientations*, I first read through the critical incident stories and coded for descriptions that indicated the ABX triad, defined operationally as one individual (A) talking to another individual (B) about a topic (X) such as implementing a firefighting task. While the majority of ABX coorientations were embedded in the critical incident stories, there were several cases in which ABX coorientations surfaced in other aspects of the interviews. For example, when discussing adjustment to crew expectations, a few members mentioned instances of adjusting to the crew; a few such vignettes contained coorientations.

I separated the rule/routine coorientations by crew followed by the space-related coorientations. As I read the coorientations for each crew, I first noted the topics discussed--the specific rule or routine referenced and the context or situation surrounding the coorientation. For the second reading of the coorientations, I was looking for a broader idea of what was going on in the interactions such as the communicators' relationships to each other and their respective orientations toward the object under discussion. I noted how and why a rule/routine entered the discussion; that is, was a rule or routine being contested, negotiated or demonstrated? Spatial coorientations were less straight-forward. If space entered the conversation it

was often hypothetical and in the background of other discussions on such topics as how to implement a safety rule in a spatial terrain, as in "we typically look for X, Y, Z aspects of terrain when identifying a safety zone." Finally, after going back and forth between the data on crew *texts* and the critical incident *coorientation* data, I selected instances of coorientations for each crew and each RQ that exemplified each workgroup's *texts*.

Overall the 15 interviews with West Fork members yielded 43 critical incident stories. Within those critical incident stories, members reported 23 interactions that fit the ABX criteria of a coorientation around a rule, routine or space. The 12 interviews with Manzanita members yielded 27 critical incident stories within which there were nine interactions fitting the ABX criteria for a coorientation around a rule, routine or space.

I then analyzed the transcripts to identify the texts of each crew. A text is a record of past conversations that reference the organization and serve as a basis for members' ongoing instantiations of the organization (Robichaud, Giroux, & Taylor, 2004). Coorientations and texts mutually inform one another. Coorientations indicated the ways that each workgroup's normative routines were being instantiated in interactions between members. However, in contrast to coorientations, texts are embedded in broader-level ideas that inform how the workgroup members interact. The crews' texts were not explicitly talked about. Instead, texts are abstracted from the interactions. As I mapped the crew's texts, I continually asked 1) how does this code/sub-code illustrate a crew's sustained practice for firefighting tasks? 2) What

ideal(s) serves as a guiding purpose that explains why their sustained practices play out as described? 3) How do each crew's expectations, norms and points of uniqueness and pride illustrate this guiding purpose? 4) What practical conditions on each crew might contribute to their guiding purpose, norms and expectations?

In the coding procedures I focused on what members said about their crew's normative ways of enacting rules and routines, normative ways of acting in general, and areas of uniqueness. Following grounded theory (Charmaz, 2006), my goal was to inductively capture a broader understanding of each crew's underlying preferences for how interactions should occur. For example, each crew had a slightly different *safety* text (among others). The safety text was a broad set of ideas for the kinds of activities that contributed to safety. Thus, West Fork members' pride in their autonomy shaped what they felt were the actions that contributed to safety (e.g., actions that demonstrate competence and self-sufficiency); their coorientations further reflected self-sufficiency as a view of safety. To contrast, Manzanita's emphasis on mentorship meant that they defined safety in terms of their crew's teaching about related activities; the mentorship view of their safety text was present throughout members' accounts of their coorientations.

Summary

This chapter has introduced a communication-based view of high reliability organizing that focuses on workgroup-level interactions that enact rules, routines and material space. A communication constitutes organization (CCO) theoretical approach examines how the organization and the individual are linked as members

share actions and, in doing so, constitute the organization (Bencherki & Cooren, 2001). The core mechanism of CCO is a dialectical relationship between *text* and *conversation* (Robichaud, Giroux, & Taylor, 2004). Texts are past instantiations of the organization that occur through interaction and are referenced in subsequent interactions. C*onversations* generate, reify or change texts. Ongoing interactions referencing the organization develop sustained practices where knowledge becomes *textualized*. As *text*, knowledge is grounded in practices such as ongoing interactions involved in problem solving, rather than individual instantiations of sensemaking. *Co-orientation* is the foundation of *conversation.* Co-orientation involves members interacting about an object, such as implementing a rule. Each member brings into the interaction his or her own organizational perspective toward the object (e.g., supervisors see rules differently than do subordinates). Members *orient* toward the object differently, and they also orient toward one another (e.g., as supervisor to subordinate and vice versa). Their organizational perspectives inform how each party negotiates what to do about the object.

Constitutive communication is located in *processes* such as how rules and routines are used differently across HRO workgroups. From this view, rules and routines enter into members' conversations--sometimes as the object of interaction, other times alluded to or implied. Rules are general directives meant for flexible application across numerous situations, and as such, require interpretation based on local norms and practices (Zhou, 1993). Routines are patterns of action that persist over time (Pentland & Feldman, 2005) and are considered "effortful

accomplishments" because unpredictable circumstances mean that routines can never be fully standardized. Communicative interactions bring rules and routines into conversation where they are interpreted and enacted, meaning that routines often comprise the local actions that enact an organization's wider-reaching rules (Becker, 2004). Therefore, if *reliability* is conceptualized as *consistent* patterns of action across the organization for enacting rules or routines, then it is important to know whether and how workgroups within the same HRO differ in their practices and interaction patterns. If there is variation across the HRO in workgroup-level enactments of rules and routines, what are the implications for high reliability, and ultimately, safety?

This chapter proposed a study that uses interpretive methods to examine crew-level interactions that influence task implementation and enactment of safety rules. Critical incidents serve as *texts* of previous *co-orientations*. Research questions asked: 1) how critical incidents from two crews compared to one another in the ways firefighters co-oriented to enact firefighting rules and routines, 2) how critical incidents from the two crews compared in the ways that firefighters oriented toward the object of material space, 3) how the texts of each crew pointed to similar and different patterns of interaction for implementing rules and routines, and 4) how the two crews' texts point to interactions that make reliability visible and facilitate learning. Critical incident narratives (Flanagan, 1954; Gremler, 2004) from two wildland firefighting crews were gathered to extract workgroup level comparisons in interaction patterns relating to local routines and application of safety rules for

managing tasks and space. The next chapter reports the findings to these research questions.

CHAPTER 3

Study One Findings and Discussion

This qualitative study examined how two workgroups compared in their routines for performing the same specialized job: heli-rappel wildland firefighting. The crews performed the same types of tasks and were subject to the same organization-level safety rules. If high reliability organizing depends on consistent and similar practices for enacting safety rules, then comparing two functionally similar workgroups can 1) unearth common practices; 2) show how the organization's rules get translated into action at the workgroup level; 3) illustrate how action is rooted in practical needs, conditions and texts of the workgroup; and 4) shed light on implications of certain practices on high reliability organizing. The first research question examined workgroup level routines for implementing safety and firefighting tasks that emerged in two crews. The interactions by which members enacted these routines were unpacked by exploring the distinctive ways that members *co-oriented,* or engaged in, organizing through communicative interaction to implement safety and firefighting tasks. The second research question examined how the two crews managed material space, and the different kinds of experiences members had which informed the crew routines for implementing safety rules on material landscapes. The third research question unpacked how past conversations (coorientations) that referenced the workgroup served as a basis for members' ongoing instantiations of the organization. The final research question synthesized

how the findings about coorientation, management of material space and crew texts affect our understanding of high reliability organizing.

Research Question One: Coorientations Around Routines and Rules

Research question one asked how critical incidents from the two crews compared in the ways that firefighters enacted routines and rules while they co-oriented on firefighting activities while they managed fires. To frame the results of this research question, I begin with an overview of the interactions described by members of the two crews regarding their orientations toward acting as individuals or as a group, and whether they tended to have explicitly stated routines or engaged in generative practices. I did this for the purpose of drawing some broad comparisons between the ways that coorientations played out in the critical incidents described by members of the two crews. This question is answered as follows: 1) a delineation was drawn between the two crews based on the broad nature of the routines that emerged; 2) this delineation was then carried through the analysis to show how it played out across four central types of routines; and 3) the co-orientational interactions comprising these routines were unpacked.

Group versus individual orientations toward interaction. Manzanita and West Fork had fundamentally different ways of approaching their interactions with one another. The Manzanita crew's critical incidents described interactions that reflected a strong sense of group collectivity. Critical incidents depicted workgroup-specific routines that served teaching and learning functions for this crew's high number of new, inexperienced firefighters. Manzanita members saw themselves as a

crew whose members functioned to train and to learn. The crew spent the season all together and they had detailed sets of actions—routines—for their major activities: assessing a fire situation together beforehand, and debriefing a fire's events after the fact. In general, Manzanita members interacted as a group. Maintaining the quality and teaching functions of their interactions was a priority.

West Fork members tended to emphasize their individuality. Critical incidents described times when members acted independently or autonomously, either being alone and having to think for one's self, or having to assert his/her will against that of a fellow crew member or a member of another crew. Because members rotated among modules on their own crew and often worked independent of their crew, they were constantly in positions of having to establish interaction patterns with new people, which required them to assert themselves and negotiate authority. It was important that members were able to assert themselves in interactions and in deciding for themselves what actions to take because they regularly worked with people about whose experience they were unfamiliar.

Explicit procedural versus subtle generative routines. The second broad distinction between the two crews was in the ways that their routines played out. Routines are local repertoires of action. Sets of action comprising routines are embedded in contexts, and they tend to solve local problems (Becker, 2004; Pentland & Feldman, 2005). In this study's data, routines were members' descriptions of their typical interaction patterns with one another. For Manzanita, the routines that emerged were explicitly stated, procedural ways their crew accomplished tasks. For

West Fork, routines emerged subtly; instead of being explicitly stated procedures, multiple members' critical incidents accounted for characteristic ways of interacting with other firefighters—either on their crew or other crews. This characteristic interaction pattern comprised a subtle routine that yielded generative ways of implementing tasks and safety.

The distinction between Manzanita's explicit procedures and West Fork's subtle generative routines reflected a fundamental difference between the interactions that the two crews reported. Of the 27 Manzanita critical incidents, 13 described drawing from or referencing their crew's "usual" ways of doing things. Out of West Fork's 43 critical incidents, 23 described instances of conflict in which implementing safety or a task was negotiated from start to finish in the interaction, without locally agreed upon workgroup-level routines to draw from. This distinction played out in co-orientation interactions that enacted three workgroup-level routines: 1) *Planning* routines refer to interaction patterns in which members accomplish a firefighting task. 2) *Rule use* routines refer to interaction in which organization-level rules are brought into conversations around implementing firefighter safety. 3) *Authority* routines refer to the ways members interact to assume a position as a decision maker. How each of these routines played out through interaction in the two crews is described next.

Co-orientations that Enact Planning, Rule Use and Authority

Enactment of routines will be unpacked using the notion of coorientation. Coorientation is the interaction process by which members (A and B) get organized, coordinating their actions through talk. The object (X) of interaction emerges as

members negotiate their different perspectives relative to issues of fact, relationship and action (Taylor & Robichaud, 2004). In this study, the coorientations were embedded in critical incidents about a wide range of circumstances such as taking on leadership positions, times when something went wrong or safety was threatened, and instances of conflict with other firefighters, among other situations. More important than the topics of the critical incidents were the patterns these accounts revealed about each crew's characteristic interaction routines for implementing tasks and safety.

Planning routine. As local repertoires of actions, routines are embedded in contexts and local problems (Becker, 2004). Manzanita members talked about their crew's locally-embedded routines. Due to the relatively even proportions of more- and less-experienced members on the crew, members fit the role of either trainer or trainee and this complementary relationship shaped how they cooriented—how they interacted with each other through evaluating situations and potential plans. Their planning routines specifically focused on ways of talking courses of action into existence.

> Philip (Manz): I was training a trainee… ***there was quite a bit of dialog as far as plan A, Plan B…*** **we talked extensively** about what the fire was doing and tactical decisions…*When we encounter a situation like that, we* ***are all discussing the scenario and the options*** *that we have*.

As a mid-level supervisor on the Manzanita crew, Philip's quote reflected his crew's typical way of going about planning their actions while traveling to a fire incident. The coorientation in this example involves the trainer (A, Philip) and the trainee (B) discussing which plan would work the best in the situation (X). The situation is the object of conversation. It is what both are focused on and oriented toward. The potential actions flow from their mutual focus on the situation itself. The planning routine has explicit and procedural elements due to the "dialogue" about "plan A, plan B…the scenario and the options." The goal of Manzanita's planning routine was for A and B to see the both the situation and the options (X) similarly, and to select actions based on those assessments. Further, the planning routine provides learning benefits for the trainees as they begin to engage in "dialogue" about "what the fire [was] doing and tactical decisions." For Manzanita, the planning routine was characterized by dialogue between A and B about the situation and action options (X). The outcome of the conversation was *which plan* would work best given the circumstances.

West Fork members had extensive experience, which meant that relationships among members were not clearly delineated. Thus, because members considered themselves to have high levels of expertise, it was often difficult for them to know who to defer to. West Fork's planning routines involved coorientations in which establishing the relationship between A and B was as much a part of the planning process as was deciding on a course of action to take.

> Stuart (WF): "We **debated** about what to do within our module… One guy was resistant [to my plan]…But [a higher ranking member] **verified** what **my initial idea** was…I took away that need to be the **stronger voice**, not shove it down their throats, but say: "**I know** this is what we need to do. This is the right way to do it."

Stuart's quote illustrates West Fork's planning routine which involved "debate…within our module" about what to do. However, before Stuart could engage in the planning process, he had to enter into the conversation. This quote illustrates how Stuart (A) "debated" with another crew member (B) who was "resistant" to his plan. A second coorientation involved the resistant member (B) with a higher-ranking member (C) in which the object (X) was the same plan Stuart had previously proposed. The BCX coorientation verified Stuart's idea and gave him traction to participate in the conversation. Thus, the object (X) of interaction was *whose* plan to use (rather than *which* plan). For West Fork, the plan is a member's possession ("my plan," "my idea," "I know what we need to do"). Because Stuart and his plan were inseparable, his challenge was to enter the conversation differently in a context in which unclear relationships between members created ambiguity and conflict ("we debated about what to do," "I need to be the stronger voice").

Which plan versus whose plan. The distinction between Manzanita and West Fork in their tendency to talk about which plan or whose plan, respectively, was clear throughout the critical incidents. Manzanita had two *whose plan* stories but the majority (13) of the stories recalled incidents in which they discussed *which plan* to

use. The converse was true for West Fork's 23 *whose plan*, and three *which plan* stories. How either crew went about its planning routine was rooted in members' interaction patterns. Manzanita's coorientations were centered on a premise of dialogue between experienced and inexperienced members in which the focus of the interaction was on defining the situation while simultaneously defining potential plans that corresponded with the situations they were seeing. For West Fork, debate characterized interactions such that the primary focus of the interaction was whose plan to use (and thus who was in charge, discussed in more detail in a later section).

The issue of participation was threaded throughout the planning routine. For Manzanita, participation was built into the local-level training-based dialogue. Relationships between members were clearly defined by a trainer/trainee orientation toward one another. Further, since their planning routine was explicit and procedural, members knew how to engage in the process because Manzanita had clear planning routines. For West Fork, "experts" were in positions to come up with a plan on their own, and their relationships to one another—as *fellow* experts—created confusion around how to interact and thus how to participate in the planning process. A subtle generative routine emerged in which members debated about whose plan to use. An important part of the planning process was entering the debate with one's plan. Thus, while Manzanita had a built-in AB interaction relationship between trainer/trainees, West Fork members' stories reflected instances in which they struggled to get into the conversation in the first place.

Constitutive versus regulatory rule use. Rules are organization-level mandates that provide broad criteria for managing a wide range of situations (Reynaud, 2005). Because rules are intentionally broad, they require interpretation. For Manzanita, interpretation of organization-level rules was deeply embedded in their local actions such that the organization's rules became absorbed into their action routines. Local practices were figure, while the organization's mandates were ground. Thus, the coorientations involved in rule use followed from the trainer/trainee relationship described previously. The following excerpt involves the organization-wide rule that firefighters must have a safety zone in place before they begin fighting fire.

> Dean (Manz): With all of our newer people, you've definitely got to be looking out the [helicopter] window and saying "okay, the wind's pushing [the fire] this way. And look how it's burning on that side. We're landing here. The first thing we've got to do, **where's the best black to get into**?"

Here, "the black" referred to areas that had already burned and would not burn again, thus, a large enough patch of cleanly-burned "black" was typically an ideal safety zone (NWCG, 2010). Manzanita's characteristic trainer/trainee dialogue approach was carried into their routines for using the organization's *safety* zone rule. Here we see the concern that less-experienced members should understand how to evaluate the situation they were flying into "The wind is pushing [the fire] this way…look how it's burning on that side." How they implemented the organization's

safety zone rule was embedded in the training-based dialogue as the more experienced member (A) posed the question (X) to less-experienced members (B), "Where's the best black to get into?" This example illustrated a constitutive form of rule use in which members negotiated an interpretation of what the rule would mean for them in practice.

In contrast to Manzanita's constitutive method of negotiating how to implement a rule, West Fork members described a regulatory approach in which organizational rules were invoked for the purpose of forcefully asserting a stance or to oppose another person's plan.

> Robin (WF): "We used a **risk management process** on one fire where one guy really was gung-ho and wanted to start doing things… And the rest of us… went through the risk management process, **just followed it down** and said no, no, no, no. And we brought that up [to the gung ho firefighter]."

The "risk management process" was a safety checklist included in the standard safety guide issued by the organization, the Incident Response Pocket Guide (NWCG, 2010). As with the planning routine, Robin described a process of entering the conversation. In her case, the safety checklist was invoked as a way to gain leverage over the "gung-ho" firefighter and to oppose his plan.

In summary, Manzanita members described bringing the organization's rules into conversation as they engaged in dialogue to decide what to do. However, their crew-level routines subsumed the organization's rules, meaning that local-level

practices (not organization-level rules) set the precedent for how members should conduct tasks. Thus, Manzanita's use of organizational rules was *constitutive* because the meanings of rules were interpreted in light of--and embedded in--workgroup practices. This meant that the ways that Manzanita members interpreted an organizational rule would be based on how it fit into one of their practices. As Dean's quote illustrates, Manzanita members embedded their implementation of the safety zone rule within their planning routine as they approached the fire. In comparison, West Fork members used the organizational rules to assert themselves. In the absence of an explicitly encouraged method for interacting (e.g., Manzanita's mentorship interaction), West Fork members invoked organization-level rules as a kind of trump card that gave them leverage over others. This practice makes plausible sense because the organization's rules were universally recognized. Because they were the standard guidelines for action across the organization, they held precedence over local, insular practices. Therefore, given West Fork's dispersed structure and expectations that members should act autonomously, it made sense that members would talk about how they invoked rules in order to assert themselves in relation to firefighters both in- and outside their crew.

Authority routines. Manzanita had several explicit procedural routines in which the nature of their interactions was *generative*, characterized by dialogue in which trainers and trainees discussed potential hazards and action options. This generative dialogue is consistent across their routines and plays a central communicative role in training less-experienced members. This routine provided

guidance to members, namely the less-experienced ones, for how they should handle most circumstances they encountered while working on the crew; that is, engage in a dialogue with somebody more experienced to discuss hazards and action options. However, even though the interaction pattern was generative, this type of routine limited members' abilities to gain authority, as the following quotes illustrate:

> Eric (Manzanita, less experienced): "We had an AAR for an assignment that was an *uneasy situation for some of our inexperienced people*. And we had broad range from, 'yeah, maybe we shouldn't have just jumped in there and did this' all the way **up** to 'I felt fine about this'… we talk about it and **both ends** usually come to **meet in the middle**. And *as a group*, **we realize** where everyone was at the time."
>
> Dallas (Manzanita, supervisor): "In our AARs it's interesting to see and hear different people's perspectives when you come back [from a fire] because then you can **explain why** you made decisions the way you did and **what we did** and **why we did it**. And you can talk about that. And [**less experienced members] learn** from that."

Both quotes illustrate Manzanita's forum for retrospectively discussing incidents among crewmembers. A primary purpose for the AAR was for less-experienced members to express concerns ("maybe we shouldn't have just jumped in there…") and more experienced members to lend insight, explaining "what we did and why we did it." This explicit procedural routine effectively limited the kinds of interactions

less-experienced members could engage in and included only those that involved a training-based dialogue. Interactions that involved dissent or conflict were incorporated into the back-and-forth dialogue, subsumed under the rubric of teaching/learning, and diffused of oppositional influence ("you explain why, and they learn," "both ends meet in the middle"). The dialogue itself reinforced the distinction between teacher and learner, which further reinforced the authority of the teacher and limited the authority of the learner. However, the clear distinction between teacher and learner created an environment in which learners could feel comfortable asking questions, expressing fears or concerns, and openly revealing their areas of inexperience.

Both crews sustained routines for interaction. The difference was that Manzanita's provided an explicit template for how to act, hence interactions played out as a dialogue regardless of the circumstance. In contrast, for West Fork, there was no *explicit* template for how to interact, meaning that members did not hold themselves and each other accountable to certain types of interaction patterns (e.g., a teaching-based dialogue model). Thus West Fork's subtle generative routines involved debating what to do and asserting themselves using the organization's rules as leverage. This pattern surfaced because invoking and asserting the self—sometimes with the help of rules—was central to negotiating what actions to take. The following excerpt illustrates this pattern:

> Andy (WF): "We had no ***size up*****,** and [higher-ranking crew member] was saying, "no, we shouldn't fight this fire at night, because we

> haven't had a chance to size it up. " So we [lower-ranking members] were like, "why don't we go *look for it* then?" That's one of the **Watchouts**-- the first one: "Fire not scouted and sized up."….[A few members] hiked down to the fire without him.

Andy's quote describes a common type of situation West Fork members discussed. Another member had assumed an authoritative position, but was making calls that Andy and others did not agree with. The person was invoking the rules arguing that with "no size-up," the crew would not be allowed to fight fire at night. Andy describes contesting the higher-ranking firefighter by invoking one of the "Watchout Situations" to justify finding and ultimately fighting the fire.

In contrast to Manzanita members whose typical dialogue circumscribed roles and reinforced one-up and one-down relationships, West Fork members were *not* explicitly limited in their possibilities for how interactions should play out. Invoking rules in a regulatory way enhanced members' authority, providing them with leverage that raised them out of one-down positions.

In summary, the distinction between explicit procedures versus subtle generative routines appears to be tied in large part to the broad goals of the two crews based on their composition of members in terms of collective experience levels, and their different staffing patterns and work styles. Manzanita members described their tendency to work together as a single unit managing their one helicopter throughout the season. They had a high proportion of inexperienced members every year making training an ongoing goal for the crew. These factors link to centralized ways of

organizing--developing explicitly stated procedural ways of handling numerous situations.

West Fork members tended to have many seasons of firefighting experience. They were typically split into modules managing each of their two helicopters, while a third module of members was available for other assignments—individually or as a small group. Their high experience levels and overall autonomy were linked to their decentralized ways of organizing and conditions. Their dispersed staffing structure prevented them from developing explicit and sustained practices. Instead, their lack of explicitly stated and agreed-upon routines meant that members used a generative approach, constantly negotiating how a task was going to be accomplished. This was a subtle routine because it emerged in almost every West Fork interview, yet members did not appear aware that their negotiating process was a standard practice for them.

Research Question Two: Orienting Toward Space

Research question two asked how critical incident stories from the two crews compared in communication oriented toward material space in firefighting tasks. The explicit procedures versus subtle generative routines carried into the ways that members oriented toward space. Ashcraft, Kuhn and Cooren (2009) propose that one way to look at organizational site is to examine how knowledge becomes embedded in space-related interaction routines. They suggest that patterns of action are enacted across space, and that space plays a central role in the ways that 1) routines unfold in the moment, and 2) how routines are repeated and maintained over time at local

levels of interaction. The present research question examines how routines and space were related to each other for Manzanita and West Fork.

There were differences between Manzanita and West Fork in the ways that they talked about space, and also in the types of experiences and insights that they had as a result of navigating it. Neither of the crews' interviews yielded specific ABX interactions around space. However, there were important differences between the two crews in the kinds of experiences they talked about and the insights derived from them.

Static action versus change. Consistent with Manzanita's other routines, the ways that they handled space were accounted for in their routines for *planning* and *rule use*, which were characterized by proactive dialogue. As with RQ1, talk brought action options into existence. Proactive talk characterized Manzanita's trainer/trainee focus, and they consistently emphasized their teaching-based routines related to evaluating a situation and discussing it retrospectively. Routines for dealing with space emerged in half of the Manzanita interviews. Four of the 11 interviewees discussed a close-call situation in which they described terrain features and physical distances to safety zones from relevant locations on the fire. But no Manzanita members talked about *changing their actions* as a result of a close call. To give an example:

> Daniel (Manz): "When we're flying into it, everybody's eyes are out the windows looking at it: *Where's the best black to get into*? You're like well, it's underneath the fire. It's on a bench. We could probably

bail off the backside [of the ridge] down to the river, or could do this, this, or this."

Daniel's quote expressed Manzanita's way of dealing with space—through local level routines that modeled for less-experienced members how to evaluate action options. In devising a plan, Daniel described an assessment of terrain features ("best black," "on a bench") and spatial proximity to the fire ("underneath the fire," "bail off the backside"). This finding was consistent with the other Manzanita findings that dealing with space was embedded in their rule use routine which was further embedded in the planning routine, as discussed in RQ1.

For West Fork, action was emphasized over proactive talk. Members did not mention discussing action options with other members, or using a specific routine to evaluate space prior to engaging in action. While this might have indeed occurred, it was not mentioned in their stories. Instead, West Fork members told several visceral accounts in which the primary lesson resulted in heightened awareness about how to manage space on fires. Their close-calls served as occasions for sensemaking (Weick, 1995) that resulted in *changes in action*. Retrospective reflection on situations showed how members *changed their actions* as a result of the experiences in which something went wrong. Six of the 15 West Fork members talked about specific experiences that caused them to change the way they dealt with space. For example, they described changing how they chose and evaluated escape routes or safety zones, and changed the criteria (or priority of criteria) used to decide how to position themselves relative to the fire. Each of these instances involved physically running

from the fire. These six stories revealed how they acted on their *constructed* configuration of spatial elements (e.g., escape routes, safety zones, physical distances). Because they ended up running for safety, they described insights regarding how, in the future, they would prioritize different information when deciding how to position themselves in relation to the fire.

> Paul (WF): "If somebody tells you the *activity picks up at 3:00 or 5:00* or something like that, then you *put that in your head*, and *you wait for that time*, and you wait to see and *be in a safer spot when the time comes*…Whereas before [the close call], I wouldn't say that I wouldn't pay attention to something like that, but when I was coming in, *I just felt secured right from the very beginning."*
>
> Ben (WF): "We probably should have landed in the black to begin with, instead of the green."

Spatial configuration. The constantly-changing wildland firefighting environment means that firefighters always deal with new and shifting sites. This situation requires that firefighters actively construct their work sites before acting in them. A site in this environment acts like the component parts of a building. With every new fire and new sets of terrain features, firefighters use the organization's rules and local routines to *build* the environment in which their actions will take place. For example, wildland firefighters look for the same basic terrain features on which to base their firefighting actions (e.g., especially areas that can serve as safety zones and escape routes, slope features that influence fire behavior, and distances between

terrain features, etc.). However, the configuration of terrain features is always different, and the ways that terrain features figure into firefighters' plans depends on the fire activity. For example, a particular safety zone may work well while the fire is a certain size and burning in a particular area, but as the fire increases in size, the safety zone may no longer be accessible or otherwise viable. Firefighters must consistently update their understanding of the spatial elements of the fire. Therefore, firefighters, in devising a plan, *construct* a spatial environment from the key components identified in their training. Standard ways of conducting this process were embedded in Manzanita's planning routine and consisted of practices for constructing spatial environments that had worked previously. West Fork interviews, on the other hand, showed how members' practices for configuring space changed as the result of close-call incidents. Their space-related practices were based on the firefighting spaces they constructed, and knowledge became embedded in, and perpetuated by, proactive practices for managing space (as with Manzanita). However, knowledge *developed* from situations that required members to change their usual space-related actions (as with West Fork members' close calls).

Research Question Three: Crew Text

Research question three asked how the two crews compared with one another based on their crew texts, and how the texts of the two crews pointed to sets of sustained patterns of action for implementing rules and routines. Recall that communicative constitution involves a dialectical relationship between conversation and text (Robichaud, Giroux, & Taylor, 2004). Conversation involves the actual

interaction between members in which they reference some aspect of the organization while they coorient on a common issue (e.g., implementing a rule or task). These coorientations that reference elements of the organization accumulate over time and become the basis for how members instantiate the organization in their ongoing local-level interactions. This abstract notion of how to enact the organization is referred to as a text. Coorientations and texts mutually inform one another. Coorientations examine the concrete interactions between members while texts are broader-level ideas that inform how the workgroup members interact. Thus texts are not explicitly talked about, but instead are abstracted from interaction. Manzanita and West Fork exhibited different *texts* around notions of *groupness*, *efficiency* and *safety*.

Groupness

The groupness text was related to activities that bound the crew members together and provided purpose and expectations for how to act and interact. For Manzanita, groupness was achieved through task-related communicative activities that built trust and cohesion. The focus on mentorship fostered an environment in which experienced members felt responsible to teach less-experienced members, while less-experienced members were encouraged to actively engage in learning. Members took pride in their learning-based practices, mentioning that they were a core strength of the crew. In order for mentorship to work in this dialogue-based format, members had to feel comfortable enough to share. Learning-based routines played an important role in facilitating crew member cohesion because sharing insights and questions required that members trust one another, while reciprocally,

trust was built through sharing. Further, members were not concerned whether they would appear vulnerable; quite the opposite, "trust is built in our [debriefing discussions]…it's almost like confessional. You trust that people will respect what you have to say because we are all there to learn" (Eric, Manz). Hence, the quality of the interactions among members was emphasized more than the image members projected to each other (e.g., being highly knowledgeable or qualified).

For West Fork, groupness was achieved through non-task related "fun" activities in which members played sports together or "joked around." These fun activities were opportunities for the typically dispersed crew to create a sense of unity. However, even when engaging in fun, West Fork members were acutely aware of their crew's expectations for professionalism. West Fork members said that they were expected to act as experts. This expectation came with the perk that they were trusted to act professionally in the absence of supervision. When it came to fun and games, members differentiated between those who were worthy of being on the crew (versus not worthy) by mentioning that West Fork's definition of professionalism involved knowing the "difference between work time and play time" (Amy, WF). A sense of groupness stemmed from letting loose and having fun, and groupness was further reinforced with respect and trust when members demonstrated to one another that they knew "when play time was over." Thus in order to be respected and trusted as a *fellow* expert, members had to change both action and demeanor very quickly from fun and loose to serious and efficient.

Efficiency

The efficiency text emanated from interactions that shaped how members envisioned their ideal ways of performing their work. Because wildland firefighting takes place in changing circumstances and dynamic conditions, it requires fast action. For these reasons, the notion of efficiency came up in all interviews. There were both similarities and differences between the two crews on efficiency. Both crews described efficiency as knowing what to do, because knowing what to do meant that it could be done without delay. Both crews depicted efficiency as a visual sized-up of how firefighters on their own (and other) crews *looked, acted* and *moved*. Efficient (and thus professional) firefighters had the right *look*, meaning that they wore the proper safety equipment (e.g., hardhats, gloves, safety glasses, etc.), had their shirts tucked in, were dirty enough with ash to show that they had been working (professional), but not so dirty that they appeared to have hygiene problems (unprofessional). Second, firefighter demeanor—how they *act*—was important and refers to whether firefighters were calm, treated others with respect (on their own and other crews), if they appeared to know what they were talking about, and how collegial they were with other firefighters. Finally, how firefighters *move* indicated their efficiency (and thus professionalism). Both crews described the importance of fluid, purposeful movement in conveying that a firefighter knows what he or she is doing and can do it well.

Aside from these similarities, the two crews also diverged in their efficiency texts. For Manzanita, efficiency was also defined by members' abilities to notice and

communicate about problems and safety concerns quickly and accurately. Efficiency was rooted in being able to quickly overcome hesitation about voicing concerns. The more readily members communicated, the faster the crew was able to notice problems and carry out tasks. For West Fork, efficiency meant moving quickly and acting *without* supervision. Being efficient meant not needing guidance from others and being able to quickly figure what to do in any number of situations. In this way, efficiency was rooted in self-sufficiency and resourcefulness.

Safety

The safety text referred to abstracted notions regarding the ways that action and interaction contributed to members' abilities to develop a sense of discernment in dealing with safety. Manzanita's texts for safety were rooted in learning practices that pushed less experienced members to talk about fireline situations. Through their participation in discussions, members became accustomed to drawing from the crew's planning routines when conducting firefighting tasks and planning around potential hazards. By engaging in sustained practices designed to identify hazards and construct action options, less-experienced members received guidance as they developed a sense of discernment in prioritizing their actions and developing viable plans.

For West Fork, safety was considered to be a result of members developing the ability to think and act as individuals. For them, discernment was a product of being highly experienced, and discernment in matters of safety was demonstrated when members were experienced enough to act independently, assert their way and provide

dissenting views in a variety of circumstances and among various audiences.

Research Question Four: Coorientation/Text and High Reliability

Research question four asked how the two crews' texts point to coorientations or interactions that make consistency visible. Taken together, the previous three research questions revealed two distinct models for what constituted high reliability organizing in the wildland firefighting context. I argue that both the Manzanita and West Fork crews demonstrated the key elements of high reliability. However, they did so through different actions and interactions drawn from crew-specific needs.

Manzanita and High Reliability

From a high reliability standpoint, the primary strengths of the Manzanita crew included 1) the mentorship orientation members had in relation to each that encouraged dialogue, and 2) their sustained practices around the proactive evaluation of situations and the discussion of potential action options.

Consistent action. Manzanita's routines for planning and rule use involved a mentorship-based dialogue. Staffing patterns that kept the entire group together as a single unit enabled Manzanita to maintain their dialogue routines. Because they maintained this routine, members became accustomed to the expectations that they were to participate in planning and learning-based discussions. They knew they would be expected to share what they thought, which in turn meant that, in-the-moment, they were thinking about what to say about the circumstances they encountered. As a result, they were actively observing firefighting actions and events going on around them in the physical environment. Thus, Manzanita's consistent

learning and planning-based discussions kept members proactively mindful and observant. The expectation to participate in dialogue helped members do so without fearing social costs or being intimidated by those in higher levels of supervision.

Making hazards visible. Talking together about options for ways to fight fires contributed to making reliable outcomes visible for members by evaluating potential problems and discussing the merits of landing sites and safety zones. Manzanita's practice of talking through options is a communicative episode that includes the articulation of options on how to engage, including the option not to engage. As a result of proactively discussing hazards, Manzanita members talked *choice points* into existence. Also important in these dialogue exchanges, the more experienced members *modeled* choice points for the less-experienced members. Due to the constantly changing fire conditions and terrain features that wildland firefighters encountered, this practice of modeling choice points enabled less-experienced members to witness a concrete process for how to apply the organization's broad and relatively abstract safety rules while being guided by fellow crew members to visually identify important features of the firefighting environment.

West Fork and High Reliability

Consistent routines. If high reliability is the consistent avoidance of catastrophic events, then the routines that make reliability visible become important. Consistent routines were more difficult to detect for West Fork than for Manzanita. Consistency was not rooted in overt routines that crewmembers talked about. Rather, West Fork's consistency was in the crew's collective acceptance that they must act as

experts. This expectation caused them to see themselves as such, and it appeared to empower them to think of ways to enhance their authority. Thus a consistent routine that emerged was the use of rules as leverage to gain authority and to assert themselves or reject another firefighter's plan. This interaction is an important practice because part of acting as an expert was being comfortable acting as the authority who took charge. Thus, the critical incidents demonstrating the authority and rule use routines revealed how members were beginning to see themselves as the experts they were expected to be. Gaining practice with asserting oneself in order to promote a plan or when dissenting from somebody else's plan contribute to safety because it means that more viewpoints are taken into account in a complex situation, which enhances requisite variety (Weick, 1987).

Making hazards visible. A central aspect of West Fork's safety and efficiency texts was around the notion of autonomous action. However, members might not trust their abilities to act autonomously if they did not feel comfortable about their ability to recognize hazards. Because reliable outcomes can be invisible when everything goes well (Weick, 1987), brushes with danger became important opportunities to uncover or prioritize hazards, which roots that knowledge in memorable experiences. In the space examples, West Fork members described experiences of having to run from the fire due to inadequate safety zones. These types of close-call experiences seemed to punctuate firefighting careers, possibly serving as defining moments in their professional backgrounds. The richness of the narratives was due to the magnitude of circumstances they faced and contributed to

an embodied way of knowing that was carried forward. This knowledge became embodied because it directly resulted from members' experiences, was rooted in their senses, and highlighted the importance of certain safety actions: *obtaining* a weather forecast, *anticipating* how the fire will change throughout the day, *being* in a better spot when the time comes, etc. Before their experiences of running from fire, these activities were blurred into the overall milieu of firefighting actions.

High Reliability for Whom?

The ways that West Fork and Manzanita operated seemed to contribute to the kinds of situations they encountered. Manzanita described an intentional dialogue among members to assess situations and decide on how to proceed. Their modeling of a safety-conscious decision process for less-experienced members meant that they likely made relatively conservative decisions, choosing not to take on too much risk, and as a result, likely not to encounter situations that required running to safety. West Fork members, on the other hand, faced the expectation that they would make decisions independently. Because their actions were not being explicitly modeled for other members, they found themselves likely taking on more risk than if they were modeling their decisions for others (the way Manzanita members described). Thus, West Fork members found themselves in situations involving more surprise, more visceral impact, and more efforts to root their experiences in the senses. This rooting of experiences in the senses might heighten their awareness of what factors to prioritize, as Ben and Paul recognized how the time of day contributed to their anticipation of fire behavior and thus their proximity to their safety zones.

In summary, these findings showed that the mix of expertise on the crew mattered because it influenced the interaction patterns by which expertise was gained. For example, inexperienced firefighters should not work on crews like West Fork in which the majority of members are highly expert because the interaction patterns are not in place to facilitate learning for an inexperienced firefighter. There might also be pressure to conceal a lack of experience in order to save face, which could compel inexperienced firefighters to accept a great deal of risk unwittingly. Instead, crews like Manzanita, with a mix of roughly half experienced and half inexperienced members, are more likely to have routines in place to facilitate learning. Further, expert crews like West Fork offer invaluable opportunities for firefighters who already have a solid foundation of knowledge and on-the-ground experience. Being pushed to work autonomously, assume authority and take responsibility for managing extremely complex circumstances prepares these individuals and crews to take the lead in safely dealing with the increasingly large-scale complexity of wildfire disasters in a safe manner.

Summary

This study examined how two workgroups compared in their routines for performing wildland firefighting work. The results revealed key differences between Manzanita and West Fork crews. Manzanita's members had less experience overall and the crew had high annual turnover; West Fork's members had more experience and the crew had low annual turnover. The crews spent roughly equivalent time

engaging similar types of fire assignments during a typical season. These crew differences emerged in answering the research questions, as follows:

The first research question examined workgroup level routines for implementing safety and firefighting tasks that emerged in two crews. The interactions by which members enacted these routines were unpacked by exploring the distinctive ways that members *co-oriented,* or engaged in, organizing through communicative interaction to implement safety and firefighting tasks. The crews differed substantially on three routines: *planning*, *use of safety rules* and *authority*. Differences in experience level played the most crucial role in shaping the ways that Manzanita and West Fork members co-oriented when implementing rules and routines.

The second research question examined how the two crews managed material space. Manzanita and West Fork members told about different kinds of experiences related to implementing safety rules on material landscapes. For Manzanita, space was managed in the course of implementing planning and rule-use routines as they evaluated the fire and identified which terrain features to use as safety zones. In contrast, several West Fork members described close-call incidents in which their safety zone was inadequate and they had to run from the fire. These experiences created a visceral understanding of space that caused them to change their subsequent implementations of safety zones.

The third research question unpacked how past conversations (coorientations) that referenced the workgroup served as a basis for members' ongoing instantiations

of the organization. The Manzanita and West Fork crews had different *texts.* This was evident in the ways their teams defined the notions of *groupness*, *efficiency* and *safety*. For Manzanita, groupness was achieved through task-related communicative activities that built trust and cohesion. Efficiency was defined by members' abilities to notice and communicate about problems and safety concerns quickly and accurately. Safety was rooted in learning practices that pushed less experienced members to see and talk about fireline situations. For West Fork, groupness was achieved through non-task related "fun" activities in which members played sports together or "joked around." Efficiency meant moving quickly and acting without supervision. Safety was considered to be a result of members developing the ability to think and act as individuals.

The final research question synthesized how the findings about coorientation, management of material space and crew texts affect our understanding of high reliability organizing. Findings from this study suggest that both Manzanita and West Fork crews operate as models of high reliability organizing, but that each crew environment is better suited for some firefighters more than others. Specifically, less experienced firefighters should seek employment on crews such as Manzanita which focused on encourages open dialogue and learning. In contrast, firefighters who have a baseline of experience should seek employment on crews like West Fork where they would be pushed to use their expertise and gain deeper experience through facing tough challenges.

Further implications of these findings will be discussed in Chapter 6.

CHAPTER 4

Study 2 Literature Review and Methods

Safety Climate and High Reliability Organizing: Workgroup Conditions that Foster Safety-Based Communication Activities in Wildland Firefighting

In most organizations, the ultimate goal is productivity. In some industries, high productivity refers to high manufacturing output, while in others it refers to successful emergency response outcomes. Regardless of industry, achieving productivity goals often relies on two factors: 1) developing processes that produce reliable results, and 2) overcoming time pressure. In high reliability organizations (HROs), members face an added pressure: they must work reliably and under time pressure, and they must do so safely. Consequences of failing to act safely are far greater than low productivity, and potentially include accidents or fatalities. Because implementing safety tends to require extra steps and take extra time, safety often is seen as an obstacle that hinders workers' efforts to meet production demands.

Safety climate research addresses production pressures in manufacturing, industrial and transportation environments, among others. Safety climate refers to the extent to which workers believe their organization truly prioritizes safety, specifically, the extent to which members feel that safety behaviors are privileged or marginalized (Cooper & Phillips, 2004). The notion of "climate" refers to attitudes about safety. Safety climate simultaneously influences the degree to which supervisors and members value and implement safety activities while it also is an outcome of worker

actions. In HROs, members must coordinate to accomplish tasks, so it is important to consider the degree to which members include and value safety-related activities.

Safety climate is equally applicable for both HROs and manufacturing contexts because it addresses social pressures in work environments that contribute to members' comfort levels around implementing safety and voicing concerns. The current study brings safety climate and HRO research together to assess how workgroup level activities and attitudes enable or constrain consistent safety actions across a large decentralized organization. Study One provided preliminary information about crew-level communication and interaction dynamics that can be assessed across the wildland firefighting organization. Findings revealed that wildland firefighting crew conditions importantly enabled, and at times constrained, a crew's ability to develop sustained safety routines. These conditions include 1) staffing patterns (working together or divided), 2) work styles (task interdependent, independent) and 3) the existence and value of communication and learning routines. Furthermore, safety activities and work styles were closely related to the degree to which wildland firefighters felt social pressure from their workgroup to accept hazards when safety measures were not in place.

Bringing together the HRO context, safety climate research, and findings from Study One, the present study addresses three research aspects of crew safety climate, 1) how crew staffing patterns (co-located, dispersed) are related to work style (independent, task interdependent), crew communication activities and the crew's interaction environment; 2) how independence and task interdependence

relate to each another in the context of wildland firefighting work; and 3) how crew communication activities shape (and are shaped by) aspects of the crew interaction environment.

This study examines a communication-based view of workgroup-level safety climate, proceeding as follows: First, I will review safety climate literature (including major concepts and findings). Second is a discussion about the importance of the workgroup for facilitating communication-based practices. Third, I propose a safety climate study of wildland firefighters. Hypotheses build on both the findings from safety climate literature and Study One.

Safety Climate

There are abundant studies on safety culture and climate. Even though the words safety culture and safety climate often are used interchangeably, the two constructs are distinct from one another. *Culture* investigates an organization's values, assumptions and artifacts, while *climate* encompasses the actions that manifest the culture (Schein, 1992). When applied to safety research, these constructs are used to investigate similar phenomena, but they do so following different paradigmatic and methodological approaches, and at different levels of analysis.

Studies on safety culture typically use qualitative methods to unpack how the culture of an organization influences safety actions. Safety culture refers to broad *attitudes*--beliefs and values about people, work, the organization and the community that are shared by most members within the organization (Guldenmund, 2000). This approach analyzes the underlying structure of symbols, myths, social drama, and

rituals manifested in the shared values, norms, and meanings embedded in an organization's processes. (Mearns & Flin, 1999). The strengths of a culture-based approach are rooted in its qualitative methods that capture rich detail describing how the organization's larger goals create and perpetuate pervasive, yet covert, value systems. Of interest is the organization as a whole and its centralized systems of meaning.

Compared to safety culture, climate studies adopt a narrower focus that addresses the context in which behaviors occur (Schein, 1992). Safety climate examines how social and production pressures in the work context function as frames of reference that guide action (Guldenmund, 2000; Zohar, 1980). Research investigates the extent to which workers believe their organization, managers and co-workers privilege or marginalize safety behaviors (Cooper & Phillips, 2004). Among the safety climate research is the assumption that workers are motivated to engage in safety conscious behaviors when they believe that their efforts to behave safely are important or valued (Morrow, et al., 2010). However, the more compelling issues that safety climate studies address relate to influences in the social environment that pressure workers to disregard safe actions. This research points to several core facets of safety climate that promote and inhibit safe action.

According to Morrow et al. (2010), research on safety climate identifies four common facets of the construct. First, the *hierarchical social environment* refers to manager's attitudes toward safety and members' perceptions that managers value employee well-being and safe behaviors. Second, the *lateral social environment*

refers to the perception that peers value safety. Among peers, social cues for the types of behaviors that are expected and accepted become important. Third, the realities of the *job itself* are referred to as the tension between work pressures and safe actions. A fourth facet of safety climate includes the *incentives* provided for acting safely. The first three facets are most commonly assessed (see Hofmann & Mark, 2006; Lu & Tsai, 2008; Zohar, 1980) while the fourth, incentives, is less-often examined this is likely because researchers and practitioners tend to be more interested in factors that obstruct safety (Morrow, et al., 2010).

As previously mentioned, assessing the primary facets of safety climate involves segmenting the social environment into hierarchical and lateral social influences as predictors on worker behavior. This approach fits with organizational environments in which there is a clear functional difference between managers and workers (e.g., an assembly line). However, emphasizing hierarchical and lateral pressures may not offer the most applicable results in HRO contexts. For example, wildland firefighting workgroups involve all levels of the crew hierarchy to collectively perform firefighting tasks. This functional similarity across levels of the workgroup chain of command means that sources of production and safety pressures may be rooted in collective processes such as routines. Focusing on the workgroup level for analysis brings into focus how staffing patterns and work styles, communication activities, and the interaction environment interrelate to influence a workgroup's safety climate.

Safety Climate and Workgroups

Several safety climate researchers embrace the workgroup unit of analysis arguing that workgroups mediate the relationship between organizational climate and safety behavior (see Zohar & Luria, 2005). In HROs, workgroups are the social environments in which members' relationships are highly interdependent for both learning and for functioning safely (Myers & McPhee, 2006). Further, a communication perspective emphasizes that the workgroup is the level at which an organization operates as a coherent unit of action and intention (Taylor, 2009). Workgroup safety encompasses sets of behavior expectations that help workers make coherent sense of the complexity and ambiguity they face in their regular work activities. This is important to consider because HRO members cue one another as they coordinate to manage complex circumstances.

Safety climate and high reliability. HRO theory and research center on ways that organizing processes contribute to the avoidance of accidents. For this reason, high reliability organizing is considered to be a mechanism for safety. HRO theorizing comes from a variety of angles to explain how safe operations are possible (see review in Study One). Underlying much of the work is the idea that high reliability refers to some level of consistency in implementing safety, whether the consistency is rooted in organization-level coordination or individual-level action or thought.

The organization-level theorizing explains how an organization operates as an interconnected whole. For example, Weick & Roberts (1993) explain how numerous

units and subunits on an aircraft carrier coordinate the constant take-off and landing operations of fighter jets. That particular HRO is characterized by its consistent patterns of inter-unit coordination within tight margins of error, and the system is examined as a cohesive, and highly reliable whole. The other prominent view of high reliability examines individual-level cognition. Cognitive perspectives on high reliability organizing examine processes by which members develop mental representations of the environment; this research focuses on processes of noticing and prioritizing external stimuli (Reason, 1997; Weick, 1993, 1995). The influence of social pressures often is ignored in this work. Therefore, I propose that the workgroup level of analysis can bridge between the organization- and individual-levels of HRO theorizing. Further, a safety climate approach acknowledges how social and production pressures inform action and interaction (Zohar, 1980; Zohar & Luria, 2005).

If highly reliable organizing, and thus safety, depend on some level of consistency in action, it is important to consider that there may be substantial workgroup-level variation in safety climate across a single organization. This variation in safety climates means that the social environment and staffing patterns of workgroups, combined with the collection of member experience levels (among other factors) shape what safety activities are implemented and how. Workgroup-level attitudes toward safe action may influence the degree to which safety activities are incorporated into crews' regular activities. Further, safety climate influences how members interact with one another when implementing tasks and safety. Patterns of

action that emerge in workgroups as a result of the safety climate may have crucial implications for high reliability.

A Communication Perspective on Safety Climate

I propose a communication-based view of high reliability focusing on conditions that foster communicative activities related to learning about and implementing safety. A communication perspective on safety climate focuses on action and interaction (rather than cognition or systems). A communication approach assumes that a workgroup's "typical" ways for implementing safety are heavily shaped by what the workgroup members collectively consider to be appropriate action. A communication approach examines the presence of safety activities and the conditions that enable and constrain communicative interactions around safety. The next section briefly presents findings from Study One that were most germane in influencing the safety activities and climates of two wildland firefighting crews. Findings from Study One will be presented alongside concepts from the safety climate literature. Finally, I propose a study of safety climate in wildland firefighting workgroups.

Communication-Based Dimensions of Safety Climate

Study One involved a qualitative analysis comparing how two highly specialized helicopter rappel wildland firefighting crews implemented safety routines. These two crews, Manzanita and West Fork, performed the same job tasks, but findings showed these crews operated quite differently due to member experience levels and crew staffing patterns.

The Manzanita crew employed 20 firefighters and managed one helicopter. All members worked together for the entire season, with the exception of a few higher-level supervisors who were occasionally able to work apart from the crew. Their consistent co-located staffing patterns meant that they were able to maintain communication-based learning activities. Members described their regular learning-based discussions as a point of pride that generated a sense of collective purpose around the complementary notions of mentoring and learning.

In contrast, the West Fork crew employed 25 firefighters seasonally. The crew managed two helicopters, which were often assigned to separate fire incidents. The 25 members rotated among three locations throughout the summer: working with either the first helicopter, the second helicopter, or they were stationed at the base. Members reported working with different personnel from their crew on each of their two-week rotations, and a large part of the crew was qualified to take on individual assignments to fill various roles on large fire incidents. Members reported that they were expected to act autonomously as experts. Independence and self-sufficiency defined West Fork's interaction environment, contributing to its notable lack of collective communication activities. Members strived to have their actions match their expert reputation, but sometimes felt pressure to take on hazardous tasks as a result.

Safety climate acts as a frame of reference that shapes expectations and guides behavior (Guldenmund, 2000; Zohar, 1980). Applied to Study One findings, the two crews reported different expectations and frames of reference that informed

how they were to implement firefighting tasks and safety. Manzanita contained a mix of experienced and inexperienced members. The crew operated from a teaching/learning frame of reference, and crew expectations involved the pressure to actively engage in learning activities. In contrast, West Fork was so highly experienced that their frame of reference was as experts; they acted on the expectation to take on hazards they felt their crew was uniquely qualified to handle.

Study One findings pointed to three important contributors to safety climate in wildland firefighting workgroups that affected how members implemented safety: 1) crew *staffing patterns* and *work styles* influenced whether crews were able to develop sustained communication and learning routines; 2) the workgroup *interaction environment* involved feelings about the quality of the group's work, interpersonal comfort, and workgroup-level pressures to take on hazards; and 3) the presence and value of *communication-based activities* influenced crews' acceptance of hazardous work assignments. In the next sections, I describe these three safety climate dimensions, introduce concepts within each dimension, and propose research questions and hypotheses.

Workgroup Staffing Patterns and Work Styles

One defining characteristic of HROs is that members frequently encounter new situations and gain knowledge that is highly situational or idiosyncratic (Rochlin, 1993; Weick, 1987; Weick, 1993). Having a dependable forum in which to share idiosyncratic experiences allows members to engage in collective sensemaking activities designed to share and solidify members' insights (Weick, 1987). However

staffing patterns may directly influence whether the workgroup is able to maintain a dependable routine such as gathering to debrief about the previous work shift. Such workgroup staffing patterns include co-located or dispersed configurations of members. Further, work style refers to a crew's typical orientation toward accomplishing tasks—do they perceive that their tasks require collective effort (task interdependence), or individual action (independence)? Workgroup staffing patterns influence how the crew operates as a collective. Work styles affect how members orient toward each other in their interactions (Sole & Edmondson, 2002). Both of these workgroup conditions are discussed next.

Staffing patterns. Communication and learning practices are mechanisms for workgroup members to make sense of situational ambiguity and for highlighting hazards. However, a workgroup's staffing patterns influence whether certain practices become a dependable facet of crew life. To illustrate the importance of staffing patterns, Sole and Edmondson (2002) examined how geographically dispersed teams developed and shared *situated knowledge*, defined as knowledge grounded in co-located work practices. They found that knowledge that was shared locally was unlikely to be shared among dispersed group members unless those members already had a history of interacting extensively with the centralized group. In order for situated knowledge to be shared with dispersed members and be beneficial to them, members had to be *aware* of the relevant situated knowledge. In other words, they had to *know* about the knowledge in order to *ask* about it. Further, they found that knowledge was embedded in co-located members' work tasks, taken

for granted and invisible. For these reasons, co-located members did not know to point out insights to distal members. Sole and Edmondson's study highlights that idiosyncratic knowledge and insights often are made sense of in a group's social interaction patterns. An implication of these findings is that groups whose members are co-located into a single unit can maintain the kinds of interaction patterns that provide a forum for sharing individual knowledge and insights, embedding them as workgroup-level knowledge. In contrast, workgroups whose members are not consistently co-located may lack stable interaction patterns that provide a forum for learning-based communication activities.

Study One revealed that there were substantial differences between Manzanita and West Fork further suggesting that there is a large degree of inconsistency across the broader wildland firefighting organization regarding safety implementation. However, findings showed that there were key enablers and constraints influencing whether the crews were able to develop sustained communication activities. For example, Manzanita worked together as a co-located unit the majority of the time and was able to maintain communication and learning practices more easily than West Fork whose members were dispersed across multiple sub-groups or were working on autonomous assignments apart from the crew. In addition to staffing patterns, another component of safety climate is the degree to which members feel their work requires coordination with others, discussed next.

Independence and task interdependence. Wageman and Gordon (2005) investigated how it is that, among groups whose tasks are structurally identical, some

groups operate as interactive teams while others operate as individuals working independently from one another. Following Deutsch (1949, 1973), they built on the assumption that team members interact based on what they perceive are their workgroup's goals and values. This research highlights that the workgroup—in defining its goals, values and sense of group identity—constructs an image for their normative ways of approaching work tasks. Wageman and Gordon found that members viewed their workgroup as highly task interdependent when the group's values were egalitarian. In addition to being task interdependent, members of egalitarian groups tended to engage in a great deal of information exchange when accomplishing tasks. To contrast, groups that held meritocratic values tended to view a task as a set of individual sub-tasks, which members could accomplish independently and with limited need for information exchange. These findings echo Pearce and Gregerson (1991) who found that task interdependence and independence are not objective assessments of the amount of coordination required in work tasks. Instead, the measures reflect members' subjective perceptions about whether their work requires coordination (as opposed to individual action).

The above studies highlight three important issues. First, the workgroup's values defined how members understood their relationships with one another—as either task interdependent collaborators or as lone implementers. Second, the workgroup's collectively-held view of its task interdependence (or independence) influenced the degree to which members felt that communicative interaction was necessary for accomplishing tasks. Third, these findings suggest that there is no

inherent or self-evident way of accomplishing a task. Rather, workgroups construct their task-based practices based on the values they privilege (in Wageman and Gordon's case, egalitarian or meritocratic), combined with members' understandings about how they should interact with one another (to communicate or not). Applied to high reliability organizations, these findings point to specific reasons why there can be wide variation across an organization in the ways that workgroups accomplish tasks the organization might consider to be "standard" procedures. Applied to safety climate, this research reinforces that workgroup level patterns for relationship and interaction influence the degree to which implementing safety is seen as a unified endeavor (versus a set of individual tasks), and the degree to which communicative interaction is viewed as a necessary and valued process for facilitating work and safety.

Interaction Environment

Wildland firefighting is an organization that exists for the purpose of performing hazardous work. Even the name suggests the manner by which a large-magnitude hazard (wildland fire) should be dealt: with aggressive action ("fighting). Thus the pressure for firefighters to accept hazardous work is built into their occupational title. In this case, there may not be a clear distinction between "hazardous" versus "safe" action. Instead, notions of hazards and safety may be intertwined with other ideas, as follows: 1) The crew's capability to take bold action may involve pressure (e.g., from supervisors or co-workers) to actively engage risks at the expense of safe behaviors (work safety tension). 2) Crews may take pride in,

and be well regarded for their approaches toward "fighting" fire (crew prestige). Finally, 3) the level of interpersonal comfort among crewmembers may enable them to advocate for more- and less-bold approaches to their work (psychological safety). These three aspects of the interaction environment are relevant to the wildland firefighting context and are discussed next.

Work Safety Tension. Work safety tension refers to the degree to which members feel their organization values production over safety due to an unsafe work design or social conditions that reward maximum productivity (Morrow, et al., 2010). Work safety tension takes into account perceived effects of required work pace on safety (Zohar, 1980), employee risk perception (Brown & Holmes, 1986), and workers' involvement in implementing safety (Debobeebler & Beland, 2000). Applied to the wildland firefighting context, work safety tension addresses the pressure to engage hazardous circumstances when members feel that safety is not fully implemented. This concept is important because wildland fire hazards can be ambiguous, situations change suddenly, and members may face pressure to act quickly, sometimes at the expense of completely identifying and addressing hazards.

Crew prestige. A crew's prestige is defined as "the degree to which the [crew] is well regarded both in absolute and comparative terms" (Mael & Ashforth, 1992, p. 111). Mael and Ashforth argued that an institution's prestige influenced the degree to which members aligned their values with the institution. Applied to the crew level, being associated with a highly regarded crew can boost member self-esteem and encourage members to align their values and actions with those of the

crew. The crew's prestige is an important contributor to safety climate because members may match their actions to those they consider to be "typical" of the crew or actions they perceive to be highly regarded in the practitioner community.

Psychological safety. Psychological safety addresses the quality of interpersonal relationships in the team environment (Morrow, et al., 2010). Studies show that the climate of the workgroup must be free from ridicule if members are going to feel free to take actions that provide for their wellbeing (Cannon & Edmondson, 2001; Edmondson, 1999; Morrow, et al., 2010). If the climate involves ridiculing those who enact safety, voice concerns or ask questions, then members may be reluctant to take precautions that could protect them from job hazards.

Taken together, work safety tension, crew prestige and psychological safety create an environment that influences how communication-based routines are valued, and influence member comfort level with participating in crew processes in general, and specifically those that are communication-based.

Communication Activities

This section introduces communication-based facets of a workgroup safety climate. The openness of communication is a central predictor of *positive* safety climates (Hofmann & Stetzer, 1998). Edmondson (1996) found that positive safety climates resulted from employees feeling free to openly discuss safety, in addition to managers being committed to handling safety in a non-punitive way. On the other hand, characteristics defining negative safety climates included employees fearing blame or punishment, and showing wariness to raise safety concerns (Edmondson,

1999; Hofmann & Stetzer, 1998). These studies highlight that communication activities are central to safety climate because they create a forum for members to share insights. However, communication activities take on several forms and serve different functions in the group. This section introduces three types of workgroup communication: safety communication, failure learning behaviors and after action reviews (AARs).

Safety Communication. Safety communication is defined as "the degree to which workers feel comfortable discussing safety-related issues with their supervisors" (Hoffman & Stetzer, 1998, p. 649). Studies show that workgroup-level differences in safety climate are most heavily attributable to workgroup supervisors because they set the tone for how the whole workgroup acts and interacts. For example, workgroup climate is influenced by supervisory techniques, including how supervisors exercise discretion in the ways they implement formal procedures, manage competing demands, and balance safety with productivity (Zohar & Luria, 2005). Hofmann and Stetzer's (1998) definition for safety communication describes the *hierarchical* dimension of safety climate (Morrow, et. al, 2010; Zohar, 1980), which singles out the relationship between managers and workers. In wildland firefighting crews, there may be multiple levels of supervision due to a stratified chain of command. Thus, safety communication in that context refers to the degree to which the crew environment fosters upward communication among the various levels in the workgroup command structure. Safety communication captures the most basic

feeling that the social environment is conducive for raising safety concerns and questions, and allowing safety related communication activities to occur.

Failure-based learning. Failure based learning behaviors refer to "specific processes to help us learn from failures by not merely detecting and correcting errors, but also by challenging and exploring their underlying causes" (Carmeli, 2007, p. 32). Failure learning is distinct from safety communication because it addresses deliberate retrospective, reflective behaviors (rather than in-the-moment communication), in addition to the intentions that drive how members communicate with one another about safety. A potential consequence of failure-based learning is that this type of activity can build trust and enable bonding among members as they share their experiences with one another (Cannon & Edmondson, 2001). Cannon and Edmondson found that teams developed learning-oriented beliefs and behaviors when team leaders were able to provide effective coaching and define a clear direction for the team. A team's overall goals functioned as a frame of reference that guided member actions.

After action reviews. After action reviews (AARs) are a retrospective sensemaking process conducted in the wildland firefighting organization. The standard wildland firefighting reference, the Incident Response Pocket Guide (NWCG, 2010) describes the purpose of the AAR, stating that "the climate surrounding an AAR must be one in which the participants openly and honestly discuss what transpired, in sufficient detail and clarity, so everyone understands what did and did not occur and why" (p. xii). Four categories of questions are presented for

members to discuss after their firefighting activities, including "what was planned," "what actually happened," "why did it happen," and "what can we do next time" (NWCG, 2010, p. xii). AARs are a specific type of learning activity. However, because AARs are a standard procedure in wildland firefighting, there may be wide variation across the organization in crews' use and value of them. Thus, even though AARs are a form of group learning, they may not always be used and valued as such.

Research Questions and Hypotheses

The purpose of this study is to build on Study One findings that staffing patterns and work styles, interaction environment, and communication activities interrelate to shape wildland firefighter workgroup safety climate. The previous section introduced key concepts based on Study One and the safety climate literature. This section proposes three research questions to guide the investigation. For each research question, I pose a series of hypotheses predicting how I anticipate the variables will interrelate in the wildland fire context given the Study One findings.

This study investigates how various social and structural influences shape wildland firefighter safety climate. Staffing pattern (co-located, dispersed) and work style (task interdependence, independence) are treated as independent variables, but work style also is used as a moderating variable. Because I my intent is to examine various configurations of variables, I did not designate any of the concepts related to communication activities (safety communication, failure learning, AAR value, AAR frequency) or interaction environment (crew prestige, psychological safety, social work-safety tension) as being strictly independent or dependent variables.

RQ1: How does crew staffing pattern (co-located, dispersed) relate to work style (independent, task interdependent), crew communication activities and aspects of the crew interaction environment?

Findings from Study One showed that Manzanita was co-located (in the sense that they always worked together) and learning practices were in place so that learning was integrated into everyday activities. For West Fork, their constant dispersion and rotation among various modules meant that member learning was rooted in individual, reflective processes rather than group-based learning activities. Following the findings related to staffing patterns and communication activities, the following hypothesis is proposed.

> H1: Co-located crews will significantly differ from dispersed crews reporting lower independence and higher task interdependence, safety communication, psychological safety, and failure-based learning behaviors.

RQ2: How are independence and task interdependence related to one another in the context of wildland firefighting work?

Findings from Study One indicated that wildland firefighters' tasks involved both task interdependent and independent aspects simultaneously. For example, when conducting a cargo mission involving moving supplies from one part of the fire to another using a helicopter, a helitack firefighter is engaged in a highly interdependent

task; it involves coordinating with immediate co-workers who are preparing the cargo for flight, the helicopter pilot who will fly the cargo, and the party who will receive the cargo. At the same time, the firefighter must make highly independent decisions planning the number of flights, prioritizing the loads, etc. Second, and related, it can be assumed that wildland firefighting activities almost always involve some level of task interdependence because firefighting requires large-scale coordination of firefighting personnel. However, opportunities for independent action may be more novel, and closely associated with the crew types that provide more opportunities for independent actions, such as in the helitack example above. Study One results showed that West Fork had a great deal of independence but this was also connected to their prestige as experts and their felt pressure to accept hazardous assignments due to their experience. To direct the investigation of Research Question Two, I propose a series of hypotheses to compare how task interdependence and independence are related to each other and other safety-related communication and behaviors. First, different specialty areas each employ slightly different staffing patterns and require different kinds of skills and physical tools (e.g., helicopters, pumps, etc.). Therefore, because specialty areas approach firefighting tasks in different ways, each may vary in both task interdependence and independence. On this basis, the first pair of hypotheses is proposed:

H2a: Specialty areas will differ in their levels of independence

H2b: Specialty areas will differ in their levels of task interdependence.

The second pair of hypotheses compares task interdependence to independence on communication activities and psychological safety as follows:

H3a: Crew task interdependence predicts safety communication, psychological safety, failure-based learning behaviors, and frequency and value of AARs.

H3b: Crew independence predicts safety communication, psychological safety, failure-based learning behaviors and frequency and value of AARs.

Third, Study One revealed that the highly independent West Fork crew members talked about experiences in which the expectation that they would act autonomously sometimes made them feel pressure to accept hazardous assignments even when safety measures were not fully in place. Therefore, I propose the following hypothesis:

H4: Crew independence is related to high work-safety tension.

RQ3: How do crew communication activities (safety communication, failure learning, AAR frequency and value) relate to aspects of the crew interaction environment (crew prestige, psychological safety, work-safety tension)?

Study One findings showed that the Manzanita crew conducted frequent AAR discussions and highly valued the routine as a learning activity that built cohesion among members and helped inexperienced firefighters voice concerns and insights. This finding leads to the following hypothesis:

H5: Crews that report high frequency and value of AARs, high safety communication, failure learning and psychological safety will report low work safety tension.

Crew prestige is closely tied to reputation of the crew and, in wildland fire, the reputation may be tied to being a safe crew, particularly one that can coordinate together while facilitating independent thinking and action. Therefore, a mix of crew prestige, task interdependence and independence may predict the level of safety communication on a crew.

H6: High crew prestige, task interdependence and independence predict high safety communication.

Communication activities in the crew may influence the degree to which members feel comfortable in their interaction environment. The following hypotheses explore more about the relationships between communication activities and the interaction environment. Psychological safety is one type of safety climate (Morrow, et al., 2010), and refers to the overall feel that the crew environment is comfortable for interpersonal risk taking. This may be facilitated by communication-based practices and learning behaviors (Safety communication, failure learning, AAR value) as well as how the crew values itself (crew prestige) and its practices (AAR value). Therefore, the following hypothesis is proposed:

H7: High crew prestige, safety communication, failure learning, AAR value and AAR frequency predict high psychological safety.

In Study One, West Fork members frequently mentioned their crew's reputation for being highly experienced firefighters. Members talked about wanting to "live up" to that reputation. Manzanita members did not specifically mention their crew's reputation within the firefighting community, but members did frequently talk about their high esteem for their crew and their efforts to act in ways that were consistent with its mentorship-based goals. The following hypothesis predicts that a crew's prestige, or reputation, will be based on the degrees to which the crew practices and values communication and learning behaviors.

H8: Failure learning behaviors, safety communication, AAR value, AAR frequency, independence and task interdependence predict high crew prestige.

Work safety tension is important to consider in the wildland firefighting context. Study One revealed that the highly prestigious West Fork crew experienced a form of production pressure in which they felt pushed to use their expertise to address hazards that other crews were not as qualified to handle. Thus, West Fork was rewarded for taking on hazardous situations, prompting the following hypotheses:

H9a: High crew prestige is related to high work safety tension.

H9b: A crew's task interdependence moderates the relationship between crew prestige and work safety tension.

H9c: A crew's independence moderates the relationship between crew prestige and work safety tension.

Methods

This study extends key findings from Study One regarding ways that the crew-level communication environment and staffing patterns influence a crew's ability to develop sustained communication and learning based activities. A survey was employed to test the hypothesized relationships and to respond to the three research questions. This section describes the development of the survey instrument.

Measures

This study used several measures that have been validated in previous research. In this section, I define the constructs, describe their items, and report the Cronbach's alpha scores found in previous research. All of the items on the survey were adapted both for the group level of analysis (rather than individual), and for the wildland firefighting context, rather than the corporate, industrial or educational environments for which several of the scales were initially designed. Following suggested guidelines, I chose established scales for this study based on their Cronbach's alpha scores of .70 or higher (Cronbach, 1951). The questionnaire consisted of 62 items: 36 items came from established scales for five construct measures. The 26 remaining items were developed for this study and added to capture specific aspects of the wildland firefighting context; the added items are described in more detail below. This survey was internet-based. I chose to use a short survey that would require little time to complete because wildland firefighters typically work outdoors, are rarely near computers, and often work at remote guard stations with limited computer and internet access. All items are measured using 7-point Likert-

type scales ranging from 1: strongly agree to 7: strongly disagree (unless otherwise noted).

Crew prestige is defined as "the degree to which the [crew] is well regarded both in absolute and comparative terms" (Mael & Ashforth, 1992, p. 111). This construct comes from Mael and Ashforth's (1992) measure of the prestige of educational institutions as perceived by its alumni, which they refer to as "institutional prestige." I adapted eight items from the original scale (α=.79) as follows: 1) Wildland firefighters from other crews think highly of my current crew; 2) It is highly valued in the wildland firefighting community to have worked on this crew; 3) This crew is considered one of the best; 4) People from other crews look down at my current crew (reverse); 5) This crew has high standards for excellence; 6) This crew does not have a good reputation in the wildland firefighting community (reverse); 7) People seeking to advance their wildland firefighting careers should downplay their association with this crew (reverse); 8) When other crews hire new firefighters, they would not want members from my current crew (reverse).

Safety communication is defined as "the degree to which workers feel comfortable discussing safety-related issues with their supervisors" (Hoffman & Stetzer, 1988, p. 649). I selected five items from the original scale (α=.79) because they fit the wildland firefighting work context. I then developed three additional items in order to assess safety communication barriers specific to wildland firefighting crews (mentioned in Study 1 interviews). The original items include: 1) Members of this crew feel comfortable discussing safety issues with supervisors; 2)

Members of this crew feel that supervisors openly accept ideas for improving safety; 3) Members of this crew are reluctant to discuss safety-related problems with supervisors (reverse); 4) Members of this crew feel that supervisors encourage open communication about safety; 5) Members of this crew generally try to avoid talking about safety-related issues with supervisors (reverse). The three items I developed include: 6) You have to earn your right to speak up on this crew (reverse); 7) It is not the place of lower-ranking crew members to question the safety measures that supervisors have put into place (reverse); 8) It is not the place of lower-ranking crew members to point out mistakes of higher-ranking crew members (reverse).

Failure based learning behaviors refer to "specific processes to help us learn from failures by not merely detecting and correcting errors, but also by challenging and exploring their underlying causes" (Carmeli, 2007, p. 32). I used six items from the original scale (α=.89) and developed two additional items tailored to the wildland firefighting context, based on issues mentioned in Study One interviews. The original scale items include: 1) When a crewmember makes a mistake, fellow crewmembers talk to that person, not for the purpose of blaming them, but rather for the value of learning; 2) Members of this crew actively point out their own mistakes so that others can learn from them; 3) A question such as ''why do we do things this way'' is fully appreciated on our crew; 4) On our crew, crewmembers are encouraged to ask questions such as ''is there a better way for us to do our job?'' 5) On this crew, someone always makes sure that we stop to talk about our tasks and fire assignments; and 6) Any member of this crew can feel comfortable questioning the underlying

reasons for why we are doing a particular task. The two items I developed for the instrument include: 7) We are encouraged to talk openly about our experiences so that we can learn from each other; and 8) Supervisors on this crew make sure that members understand the reasoning behind decisions.

Team psychological safety is defined as "a shared belief that the team is safe for interpersonal risk taking. For the most part, this belief tends to be tacit-taken for granted and not given direct attention either by individuals or by the team as a whole" (Edmondson, 1999, p. 354). I included seven items from the original scale (α=.82) including: 1) If you make a mistake on this crew, it is often held against you (reverse); 2) Members of this crew are able to bring up problems and tough issues; 3) People on this crew sometimes reject others for being different (reverse); 4) It is safe to do things your own way on this crew; 5) It is difficult to ask other crewmembers for help (reverse); 6) No one on this crew would deliberately act in a way that undermines my efforts; 7) Working with members of this crew, my unique skills and talents are valued and utilized.

Task interdependence is the degree to which organization members' work outcomes rely on coordination with other members (Pearce & Gregersen, 1991). Existing scales measuring items similar to task interdependence were developed for corporate or manufacturing contexts, and the wording of the items seemed unnatural when applied to the wildland firefighting context. I chose this scale because it could be easily adapted to wildland firefighting while retaining the spirit of the items. The five item scale (α= .76) included the following items: 1) Members of this crew work

together closely in doing work; 2) On our crew we frequently must coordinate our efforts; 3) Our crew's performance is dependent on sharing information with each other; 4) Our job requires that members of our crew consult with each other frequently; and 5) Members at all levels of this crew are involved in making important decisions.

Independence refers to the degree to which work outcomes can be accomplished without coordination with others organization members (Pearce & Gregersen, 1991). This scale came from Pearce and Gregersen (1991) and consisted four items (α= .61): 1) Members of this crew work fairly independently; 2) On this crew, we do not need to coordinate with each other very often; 3) Members of this crew feel it is important to be able to act independently; and 4) Members of this crew tend to be self-reliant rather than depend on others.

Measures written for this study. In addition to the established scales, I developed items for this study in order to measure phenomena specific to the wildland firefighting organization. As above, the items written for this study are measured on 7-point Likert-type scales ranging from 1: strongly agree to 7: strongly disagree.

Work-Safety Tension describes "the level of inherent risk and conflict between productivity and safety an employee associates with the performance of his or her job. Employees who perceive the organization as valuing productivity over safety due to an unsafe job design or working environment may be less likely to enact safety behaviors because they are motivated to maximize productivity and rewards"

(Morrow, et al., 2009, p. 1463). I worked from their definition for work-safety tension to develop eight items specific to the wildland firefighting context as follows: 1) It is not always possible to put an effective safety zone in place; 2) Sometimes implementing safety rules gets in the way of fighting fire effectively; 3) There is pressure to engage the fire even when safety precautions are not perfectly in place; 4) There are times when beginning the firefighting response is more urgent than making sure your safety zone is failsafe; 5) My crew frequently ends up in dangerous situations where we should not be; 6) Members of my crew are experienced enough to know when a situation presents unacceptable risk (reverse); 7) It is difficult to know whether we have done enough to mitigate for hazards; 8) Crews that take on the most hazardous assignments are rewarded with a positive reputation.

After action reviews (AARs) are a retrospective group communication practice used to make sense of what happened on an assignment—what went well and what could be improved for next time. The wildland fire organization encourages crews to conduct AARs. I wrote five items to assess the degree to which members feel that AARs are valued by their crew, including: 1) Members of my crew value AARs; 2) Members of my crew actively participate in AARs; 3) AARs are an important practice on my crew; 4) Members of my crew tend to think AARs are useful; 5) On this crew, members feel that AARs are not necessary (reverse). I also wrote one item measuring how often the crew conducts AARs (7 point Likert scale: 1 = Daily, 2 = Several times per week, 3 = About once per week, 4 = About once every two weeks, 5 = A few times per month, 6 = A few times during fire season, 7 = Never).

Crew staffing patterns refer to how the crew operates during the season in terms of whether they travel together, whether the crew splits into modules, and the extent to which members work independent from their crew, etc. One item assessed the extent to which crews stay together during the season: "This crew travels together the majority of the time." The scale ranged from 1 (strongly agree) -7 (Strongly disagree).

Participants and Procedure

In order to gain access to firefighters, I met individually with three national level program administrators. First, I met with the National Helicopter Operations Manager, and the National Fire Operations Safety Officer for the US Forest Service. I then met with the Safety Director for the Bureau of Land Management. In each of these meetings, I explained the study and its applications to firefighter safety. Each connected me to crews within their respective jurisdictions to assist me in publicizing the survey to firefighting crews. Data were collected in early fall 2011 using an internet-based survey.

A total sample of 405 individuals completed the survey. Of those, 15 cases were deleted because the participants were not part of the target group; that is, they did not work directly on a crew, or were managers at higher levels of the organization. An additional 12 cases were removed because participants skipped all items in two or more entire measures. Overall, there were N = 379 valid cases.

Participants ranged in age from 19 to 60 years old, with a median age of 33 (M = 35, SD = 8 years). There were 330 males (87%), 45 females (12%); four

participants did not report their sex. Ethnicity included 277 Whites, 23 Hispanics, 11 Native Americans, four African Americans, two Asian Americans, and 62 participants did not report ethnicity. Of the participants, 108 worked on engines, 54 on Type 2 crews (handcrews, initial attack or fuels crews), 113 were from interagency hotshot crews, and 104 from helitack or heli-rappel crews. There was participation from members at all levels in the crew-level chain of command (see Table 1), including 75 superintendents, 58 foremen, 35 assistant foremen, 66 captains, 53 squad leaders, 40 senior firefighters, 49 non-supervisory members, and 3 did not report their crew position. Overall, the demographics generally represent wildland firefighting within the prominent federal wildland firefighting agencies (US Forest Service, Bureau of Land Management, and National Park Service).[10]

Because the survey was administered in early fall, the sample did not capture the seasonal workforce of college students who often have jobs as non-supervisory members and senior firefighters. For this reason, responses were heavily weighted toward the higher-level crew supervisors. Also due to missing the seasonal student workforce, fire experience and crew tenure were relatively high overall. Participants had a median of 12 wildland firefighting seasons (M = 13.15, SD = 6.82), and a median of five seasons on their current crew (M = 6.14, SD = 4.75).

The next section proceeds as follows: First, I describe how the data were screened and prepared for analysis. Second, I describe how the data were aggregated to assess constructs at the crew level, and provide descriptive statistics about the

newly-formed crew-level sample. Finally, I present tests of the internal reliabilities for each scale.

Data Preparation

The purpose of this study was to investigate how staffing patterns, work styles, interaction environment and communication activities influence crew safety climate. Due to my focus on the workgroup level of analysis, it was necessary to group individual responses by crew and aggregate them to measure the constructs at the crew-level. I screened the data for missing values, normality, outliers and skew. After screening and cleaning the sample, I aggregated responses to measure the crew level. This section describes these processes.

Missing data. I first screened for missing data points in the valid 379 individual cases. There were 25 missing scores appearing randomly and independently in the data set. Typically only one item within a measure was missing a score, so I imputed a value equal to the mean of the participant's scores on the other items within that measure. In one case, a participant failed to answer any of the items in the scale *work safety tension* but answered all other items on the instrument. This participant was among three members representing the same crew, so I imputed the mean scores from the other two members on the work-safety tension items.

Outliers and influential cases. This study uses several regression-based analyses. According to Field (2009), a fundamental concern for regression analysis is that the regression line plotting the relationship between variables is a straight one (i.e., not curved or curvilinear). The assumption of linearity is sensitive to the

influence of outlier cases because they can warp the shape of the regression line. Two standard methods for testing whether the sample contains influential cases include screening for high values on Mahalanobis distances or evaluating Cook's distances. Mahalanobis distances are calculated by running a regression analysis that plots the shape of various regression lines among the variables under study. A Mahalanobis distance measures "the influence of a case by examining the distance of cases from the mean(s) of the predictor variable(s)" (Field, 2009, p. 216). Large values may indicate that a particular case exerts excessive influence on the parameters of the model, thus changing the shape of the regression line. If Mahalanobis values exceed a critical value, then the researcher should consider deleting those cases. In my data, three of the 220 cases had Mahalanobis distances that slightly exceeded the critical value. A secondary test for outliers is the Cook's distance. Stevens (2002) suggests there is no need to delete cases showing high Mahalanobis distances as long as the Cook's distance is <1. Indeed, Cook's distances were <1 for all cases in my dataset. Therefore, I did not delete any cases or transform the data.

Normality. I examined the normality of the data by evaluating skewness and kurtosis. Non-normal data can negatively impact goodness-of-fit tests in structural equation modeling. If skewness and kurtosis are problematic, transformations should be applied to the dataset prior to SEM analyses (Kline, 2011; Lei & Lomax, 2005). There are no precise rules for determining acceptable levels of skew, but researchers generally consider absolute values of skew between 0 and 1.0 to be slightly non-normal, values between 1.0 and 2.3 to be moderately non-normal, and values greater

than 2.3 to be severely non-normal (Lei & Lomax, 2005). Skewness and kurtosis were not problematic in this dataset. I found that most of the composite variables were slightly positively skewed. Seven of the nine composite variables exhibited slightly non-normal skew including task interdependence (skew = 0.75), independence (skew = 0.32), social work safety tension (skew = -0.03), psychological safety (skew = 0.81), failure learning (skew = 0.61), value of AARs (skew = 0.71), and frequency of AARs (skew = 0.93). The remaining composite variables were moderately non-normal including crew prestige (skew = 1.13), and safety communication (skew = 1.01). According to Fan and Wang (1998), moderate skew has little effect on the standard error of parameters when using *maximum likelihood* estimation for structural equation modeling. Relating to kurtosis, Klein (2011) reports that scholars generally consider kurtosis values problematic when absolute values are greater than 10.0. The highest absolute kurtosis value in this data set was 1.42 on the composite variable crew prestige. Based on acceptable kurtosis values and evidence of moderate non-normality, I did not transform the variables.

Multicollinearity. I also examined the data for multicollinearity, which occurs when two linear variables are highly correlated (see Table 2). If the two variables are highly correlated, they are likely measuring similar constructs (Field, 2009). An examination of the correlations among all composite variables yielded no correlations higher than $r = .71$, $p < .001$ between safety communication and failure learning.

In summary, this section described how the data were aggregated, screened and prepared for analysis. Skew, normality, outliers and multicollinearity were assessed and found to be within acceptable ranges, which required no data transformations. The next section describes how the individual cases were combined to measure the workgroup level. An evaluation of the internal reliabilities of the measurement scales follows.

Aggregation Into Crew-Level Data

Once I completed screening and cleaning the data for missing responses, I aggregated the data by crew. As previously mentioned, I sorted the cases by zip code and crew type, which yielded representation from 220 crews. Of those, single respondents represented 142 of the crews while 77 crews included responses from two or more members. Second, responses from individual members were combined with their fellow crew members' responses to create a score that represented the crew's response to the item. To check whether there were significant differences between the 142 single-respondent crews and the 77 multiple-respondent crews, I conducted independent samples t-tests comparing the crew means on all the composite variables. T-tests revealed no significant differences between single- and multiple-response crews on task interdependence, $t(218) = .12$; independence, $t(218) = .54$; crew prestige, $t(218) = -1.00$; work-safety tension, $t(218) = .464$; safety communication, $t(218) = -.43$; psychological safety, $t(218) = -.75$; failure learning, $t(218) = -1.66$; value of AARs, $t(218) = -.91$; and AAR frequency, $t(218) =.-1.47$. The means, standard deviations, and alpha levels for the variables measured in the

survey are reported in Table 3.

Once aggregated, the crew-level dataset included 74 engines (34%), 60 hotshot crews (27%), 57 helitack/heli-rappel crews (26%), and 29 Type 2 crews (13%) (see Table 4). Ninety-one percent of the crews were based in the western United States (Figure 2) with the most responses coming from the following states (Table 5): California (*n* = 35 crews), Idaho (*n* = 34), Oregon (*n* = 26), Montana (*n* = 22), Colorado (*n* = 18), and Wyoming (*n* = 17).

Preliminary Analyses

This section first describes the evaluation of the internal reliabilities of the established, previously validated scales. I then describe the exploratory factor analyses conducted to examine the scales created for this survey. I used SPSS software to assess the Cronbach's alpha internal reliability scores for each of the scales. Below, I report the non-standardized Cronbach's alpha scores for each scale. Where necessary, in order to increase alpha scores for scales, I excluded problematic items from the analysis. I followed the convention for reliability scores that says: >.6 okay, >.7 good, >.8 very good, >.9 excellent, >.95 too high/redundant items (Field, 2009).

Scale reliabilities. I assessed the crew-level scale reliabilities. Several scales yielded acceptable alpha coefficients with all of their items. These included *safety communication* (α = .73), *failure learning behaviors* (α = .88), and *crew prestige* (α = .84).

The following scale reliabilities improved once I excluded problematic items

from the internal reliability test. *Psychological safety* initially yielded α=.55, but improved to α=.68 once two items were removed from the analysis: "it is safe to do things your own way on this crew" and "no one on this crew would deliberately act in a way that undermines my efforts." When applied to the wildland firefighting environment, these items may not have held the same meaning as they do in other work contexts. First, because wildland firefighters often work as a collective unit arranged in a hierarchy, the item "it is safe to do things your own way" may have been interpreted as acting against authority or the group rather than as a measure of interpersonal risk taking. Second, many wildland firefighting tasks involve numerous people contributing in small ways to a larger task, therefore, the item about others acting in ways to "undermine my efforts" may seem nonsensical considering that undermining one person's efforts would involve undermining the efforts of the entire crew.

Task interdependence was initially α=.67, but improved slightly to α=.69 after excluding one item ("members at all levels are involved in making important decisions"). As above, the typical hierarchical arrangement of the crew means that members at all levels may not be allowed to contribute to tactical decisions, even if they are encouraged to voice their safety concerns upward in the chain of command. Excluding the item from the scale improved reliability negligibly, but helped it to approach what is considered to be a "good" Cronbach's alpha value.

Four items measuring *independence* resulted in α=.59, but after excluding one item ("on this crew, we do not need to coordinate with each other very often"), the

reliability improved to α=.73. While the other items in this scale address members' preferences to be self-reliant and make independent assessments and decisions, this item seemed appropriate to exclude because firefighting is a collective task that requires coordination among members, units and resources. In this context, being self-reliant is different from taking action without coordinating with others. Failing to coordinate with other firefighters would be similar to failing to communicate about one's whereabouts and actions on the fireline, which constitutes a major safety breach.

Exploratory factor analyses. I conducted exploratory factor analyses on the two scales I created for this project, AAR value and work safety tension. The purpose of running EFAs was to assess whether the items of each scale worked together as single factors or whether the items were split across more than one factor.

I first conducted an exploratory factor analysis (EFA) on *Value of After Action Reviews* (AAR value). All items loaded onto a single factor with an eigenvalue greater than 1, and explained 66% of the variance. The factor loadings for each item were .70 or above. The Cronbach's alpha measure of internal reliability yielded α = .87.

Next, I conducted EFA on *work safety tension.* Items loaded onto two factors with eigenvalues greater than 1 using a varimax rotation. These two factors explained a total of 57% of the variance. With the exception of one cross-loaded item, all items loaded exclusively on one of the two factors. First, I deleted the single cross-loaded item ("There are times when beginning the firefighting response is more urgent than

making sure your safety zone is failsafe") because it did not clearly assess either of the two factors. Next, I assessed the items in the two factors to determine plausible reasons why those items clustered together into two separate factors, and named them as follows: 1) *social work-safety tension* and 2) *safety implementation difficulty*. Social work-safety tension was comprised of three items ("My crew frequently ends up in dangerous situations where we should not be," There is pressure to engage the fire even when safety precautions are not perfectly in place," and "Crews that take on the most hazardous assignments are rewarded with a positive reputation). This first factor yielded a Cronbach's alpha internal reliability score of $\alpha = .57$, which is considered a "poor" internal reliability (Field, 2009). The second factor, *safety implementation difficulty* was comprised of three items ("It's not always possible to put an effective safety zone in place," "sometimes implementing safety rules gets in the way of fighting fire effectively," and "it is difficult to know whether we have done enough to mitigate for hazards"). The second factor yielded an internal reliability score of $\alpha = .62$, which is considered to be "okay" (Field, 2009). Ultimately, I excluded the second factor—*safety implementation difficulty*—from analyses for two reasons: First, it did not correlate with many other of the composite variables making it somewhat tangential to the analyses (see Table 2). Second, the first factor, *social work-safety tension* seemed to better capture and correlate with the social variables under study in this investigation. I decided to include *social work safety tension* in the analyses. However, given the factor's low internal reliability, the results were interpreted with caution.

Summary

In summary so far, this study builds on findings from Study One, which revealed that staffing patterns and work styles, a crew's interaction environment, and communication activities interrelated to shape the safety climate of wildland firefighting workgroups. This chapter introduced key concepts based on both the safety climate literature and Study One findings. This study investigates how various social and structural influences interrelate to shape wildland firefighter safety climate. I proposed three research questions to guide the investigation. For each research question, I proposed a series of hypotheses predicting how I anticipated the variables to interrelate in the wildland fire context given the Study One findings. Results are presented in Chapter 5.

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[10] I did not sample within federal agencies whose wildland firefighting resources are relatively limited, primarily temporary/seasonal, or embedded in localities that lacked a central contact representative. These agencies include the US Fish and Wildlife Service and the Bureau of Indian Affairs (BIA). Sampling from the BIA might have somewhat increased representation by Native American firefighters.

Table 1

Participants' Positions on their Crews at the Time of the Survey

		N	Percent
	Superintendent	75	19.8
	Foreman	58	15.3
	Assistant Foreman	35	9.2
	Captain	66	17.4
	Squad Leader	53	14.0
	Senior Firefighter	40	10.6
	Non-supervisory member	49	12.9
	Total	376	99.2
	Missing	3	.8
Total		379	100.0

Table 2

Correlations and Significance Among Composite Variables

Correlations

	1	2	3	4	5	6	7	8	9	10
Task Interdependence	1									
Independence	.141*	1								
	.037									
Crew Prestige	.446**	.097	1							
	.000	.153								
Safety Communication	.345**	.181**	.426**	1						
	.000	.007	.000							
Psychological Safety	.338**	.128	.490**	.676**	1					
	.000	.058	.000	.000						
Failure Learning	.398**	.188**	.519**	.710**	.678**	1				
	.000	.005	.000	.000	.000					
Value of AARs	.331**	-.030	.362**	.379**	.409**	.532**	1			
	.000	.663	.000	.000	.000	.000				
AAR Frequency	.087	-.063	.178**	.124	.208**	.248**	.492**	1		
	.199	.355	.008	.066	.002	.000	.000			
Social Work Safety Tension	-.047	-.255**	-.199**	-.393**	-.286**	-.244**	-.200**	-.063	1	
	.491	.000	.003	.000	.000	.000	.003	.352		
Environmental Work Safety Tension	-.012	-.010	-.017	-.151*	-.054	-.142*	-.270**	-.133*	.427**	1
	.863	.878	.802	.026	.424	.036	.000	.049	.000	

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 3

Descriptive Statistics of Crew-Level Scales

					Skewness		Kurtosis	
	N	α	*M*	*SD*	Statistic	*SE*	Statistic	*SE*
Task Interdependence	220	.69	1.98	.69	.75	.16	.51	.33
Independence	220	.73	2.93	1.02	.32	.16	-.05	.33
Crew Prestige	220	.84	1.96	.69	1.13	.16	1.42	.33
Safety Communication	220	.73	2.09	.74	1.01	.16	1.18	.33
Psychological Safety	220	.68	2.16	.77	.81	.16	.89	.33
Failure Learning	220	.88	2.20	.73	.61	.16	.67	.33
Social WST	220	.57	5.24	.97	-.03	.16	-.60	.33
Environmental WST	220	.62	4.25	1.19	.17	.16	-.25	.33
Value of AARs	220	.87	2.38	.88	.71	.16	.72	.33
AAR Frequency	220	n/a	2.68	1.36	.93	.16	.33	.33

Table 4

Number of Participating Crews in Each Specialty Area

	N	Percent
Engine	74	33.6
T2 Hand crew, IA, fuels	29	13.2
Hotshot	60	27.3
Helitack, rappel	57	25.9
Total	220	100.0

Table 5

Number of Crews that Responded to the Survey by State

State	*N*	Percent	State	*N*	Percent
California	35	15.9	South Dakota	4	1.8
Idaho	34	15.5	Florida	3	1.4
Oregon	26	11.8	Missouri	2	.9
Montana	22	10.0	Tennessee	2	.9
Colorado	18	8.2	Arkansas	2	.9
Wyoming	17	7.7	Nebraska	1	.5
Utah	12	5.5	Illinois	1	.5
Arizona	10	4.5	Mississippi	1	.5
Washington	8	3.6	Georgia	1	.5
New Mexico	8	3.6	Kansas	1	.5
Minnesota	6	2.7	North Carolina	1	.5
Nevada	5	2.3			
			TOTAL	220	100

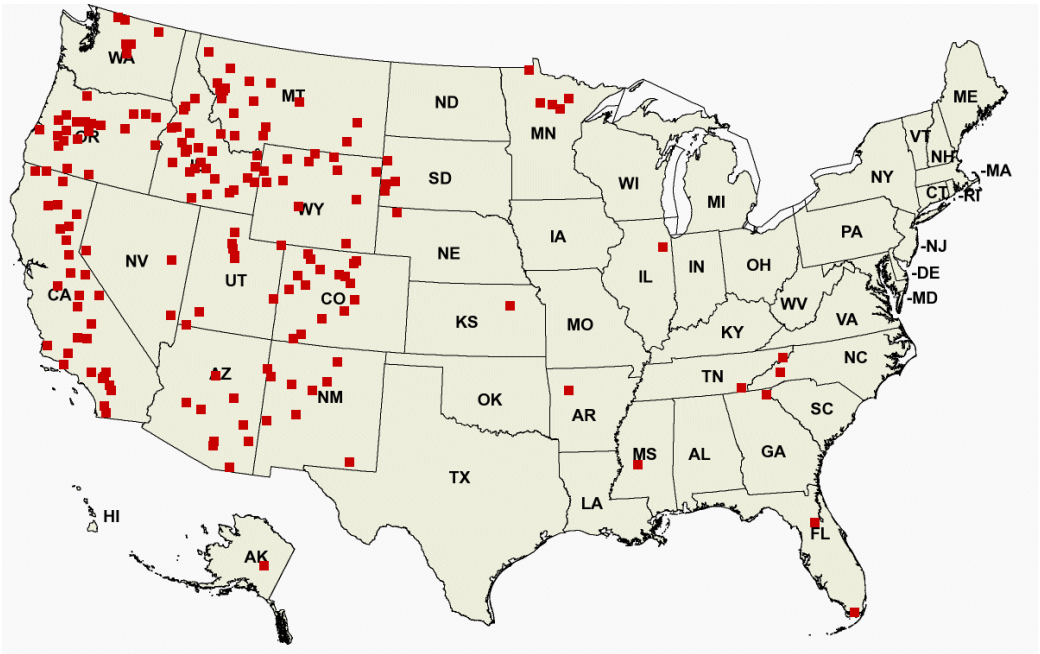

Figure 2. Geographic Distribution of Participating Crews

CHAPTER 5

Study Two Results

This study built on findings from safety climate literature and Study One to investigate how various social and structural influences interrelate to shape wildland firefighter safety climate. Three research questions guided Study Two. The first research question investigated how crews' staffing patterns influenced their work styles, communication activities and the crew interaction environment. The second research question focused specifically on work style and examined how independence and task interdependence influenced the safety climate of wildland firefighting crews. The third research question explored how crew communication activities interrelated with aspects of the crew interaction environment.

This chapter proceeds as follows. First, I present results from the first and second research questions. Second, I describe my method for using structural equation modeling (SEM) procedures to model relationships among variables in my data set. Finally, a summary section highlights the main findings and describes how they inform knowledge about workgroups, safety climate and high reliability organizing.

Results

This section presents the results of the hypothesis tests. Each of the three sections ends with a brief synthesis of the findings for its respective research question. Tables 6, 7, and 10 summarize the findings. (Please note throughout this interpretation of the results, lower numbers represent higher levels of the construct.)

RQ1: How does crew staffing pattern (co-located, dispersed) relate to work style (independent, task interdependent), crew communication activities and aspects of the crew interaction environment?

Research question one reflects findings from Study One. Specifically, Manzanita worked in a co-located manner, which seemed to facilitate regular communication-based routines and a comfortable interaction environment for members. West Fork typically worked in a dispersed manner and the crew's climate emphasized an individual, self-reliant ethic rather than group-based communication routines. The following hypothesis is based on the Study One findings, while this research question, more broadly, considers the results.

Hypothesis 1 stated that crews in which members are typically co-located (working together as a single unit) would have higher task interdependency, safety communication, psychological safety, failure learning behaviors and AAR frequency, and lower independence levels compared to crews that are typically dispersed (see Table 6). The item measuring staffing pattern asked respondents about the extent to which they traveled and worked together. Their responses ranged from 1 (strongly agree) -7 (Strongly disagree). For this analysis, I dummy coded the item that asked about staffing pattern into a binary variable that indicated *co-located* or *dispersed* staffing. Values ranging from 1-3.50 were assigned a value of 0, indicating that the crew was typically co-located; scores from 3.51-7 were assigned a value of 1, indicating that the crew was typically dispersed. A multivariate analysis of variance

compared *co-located* and *dispersed* crews on these variables. A non-significant Levene's test of equality of error variances indicated error variances were not significantly different between the co-located and dispersed test groups on any of the variables. Thus, findings from co-located and dispersed groups were interpretable.

Results showed a significant difference between co-located (n = 43) versus dispersed (n = 177) groups on task interdependency, independence, safety communication, psychological safety, failure learning, and AAR frequency. The multivariate result was significant overall $F(6, 213) = .89$, $p < .001$, but only two of the five univariate results within the model were significant.

First, the co-located and dispersed crews differed significantly on task interdependence, $F(1, 218) = 11.92$, $p < .01$. Task interdependence for co-located crews (M= 1.91, SD = .66) was significantly higher than for dispersed crews (M = 2.30, SD = .75). Second, co-located and dispersed crews differed significantly on independence, $F(1, 218) = 8.01$, $p <.01$, such that co-located crews (M = 3.03, SD = .99) reported lower levels of independence than did dispersed crews (M = 2.54, SD = 1.04).

These univariate results were consistent with the hypothesis that working together most of the time fostered task interdependency, while working in a dispersed manner creates a greater sense of independence. Co-located or dispersed crews did not differ significantly on safety communication, failure learning, AAR frequency, or psychological safety. This suggests that staffing pattern may not be a central influence (or barrier) on a crew's tendency to engage in communication activities, or

its psychological safety. Finally, there was a substantial difference in the numbers of crews considered to be co-located (n = 43) versus dispersed (n = 177). Not only were there more than four times the number of dispersed crews (nearly 80%) than co-located crews, the sample was not evenly distributed within those categories. For example, none of the hotshot crews reported being a dispersed crew, and very few helitack crews reported working in a co-located manner. Taken together, these findings indicated that crew type (rather than co-located versus dispersed staffing patterns) might have been a better differentiator on these variables. Also, if more than 80 percent of the participating wildland firefighting crews considered themselves to be dispersed crews, and thus rating higher in independence, it was important to understand the relationship between independence and communication activities and environments at the crew level. The next research question investigates and compares the influence of independence and task interdependence on safety climate.

RQ2: How are independence and task interdependence related to each other in wildland firefighting? How do independence and task interdependence compare to each other in their influence on workgroup safety climate?

Research question two asked how task interdependence and independence were related to several safety climate variables. This research question arose because the two constructs are generally presented as opposites in the literature (e.g., Wageman & Gordon, 2005.) However, findings from Study One indicated that these constructs may not act as opposites in the wildland fire context, or in general (see

also Pearce and Gregersen, 1991). To assess this research question, I proposed several hypotheses comparing the impacts of task interdependence and independence on focal variables in the firefighting context (see Table 7).

Hypothesis 2a stated that crew specialty areas would differ in their levels of independence. A one-way analysis of variance was conducted to test the hypothesis that crew types (engines, Type 2 crews, hotshot crews, helitack/rappel crews) would differ on independence, and was found to be significant $F(3, 216) = 9.75$, $p < .001$.

Post hoc tests revealed that helitack/heli-rappel crews ($M = 2.47$, $SD = 1.04$) did not differ from engine crews ($M = 2.82$, $SD = .91$), but were significantly more independent than hotshots ($M = 3.25$, $SD = .96$) and Type 2 crews ($M = 3.45$, $SD = .96$). Engines did not differ in independence compared to helitack or hotshot crews, but were significantly more independent than Type 2 crews. Finally, Type 2 crews ($M = 3.45$, $SD = .96$) did not differ from hotshot crews ($M = 3.25$, $SD = .96$) on independence level, but were significantly less independent than helitack/rappel crews ($M = 2.47$, $SD = 1.04$) and engine crews ($M = 2.82$, $SD = .91$). This result revealed a relatively wide variation in means for independence by crew type, with helitack/rappel crews reporting the most independence and Type 2 crews reporting the least. This result will be discussed in more detail next in conjunction with H5b.

Hypothesis 2b stated that crew specialty areas would differ on level of task interdependence. A one-way analysis of variance was conducted to assess whether crew types differ on task interdependence. This was found to be significant $F(3, 216) = 4.36$, $p < .01$. Post-hoc tests revealed that hotshots ($M = 1.72$, $SD = .60$) were

significantly more task interdependent than Type 2 crews (M = 2.19, SD = .75). However, neither hotshots nor Type 2 crews differed significantly from helitack/rappel (M =, 2.05, SD = .74) or engine crews (M = 2.06, SD = .66).

Taken together, H2b suggested that there was a baseline of task interdependence across specialty areas, as they did not differ much from each other. An exception was the comparison between hotshot crews--the most task interdependent--and Type 2 crews which were the least. Compared against H2a, a finding that stood out was that Type 2 crews[11] reported the lowest levels of both independence and task interdependence compared to other crew types. Together, these findings indicated that firefighting activities might involve a baseline amount of task interdependency overall, but crews differed in their access to opportunities for acting independently.

An alternative way of interpreting the findings of H2a and H2b is to think of independence as a proxy for specialized skill. Hotshots, engines and helitack/rappel crews each involve a specialized sub-set of skills for firefighting: Hotshot crews are highly efficient and integrated firefighting units; engine crews require specialized skills in water delivery through engineering plumbing systems and using pumps; helitack/rappel crews coordinate numerous types of missions using helicopters. In each of these specialties, members must not only know the skill-set, but know how to coordinate with others in using it—oftentimes when not in physical proximity to other members. For example, members from the same helitack/rappel crew might be dispersed across the same fire, coordinating missions with each other. Or, members

of an engine crew might be dispersed across various areas of a hose-lay while coordinating the delivery of water to the fire. In these examples, coordination depends on the ability to act autonomously. In other words, high task interdependence is only possible through high independence, because independence is only possible if members have the expertise to contribute to the operation. The findings for H2b showed that three of the four crew types (hotshots, helitack/rappel, engines) were similar to each other on task interdependence, while Type 2 crews differed significantly from hotshot crews. Type 2 crews are generally the least specialized among firefighting crews, so considering this interpretation of the findings, it is not surprising that they reported the lowest levels of both task interdependence and independence.

Structural Equation Modeling

The next two hypotheses and later H9b and H9c were tested with structural equation model using Amos 18.0 (Arbuckle, 2009) with maximum likelihood (ML) estimation. According to Kline (2011) ML assumes multivariate normality for the population distributions associated with each endogenous variable. The ML approach estimates the likelihood that the specified model fits the data drawn from the tested population. In this approach, the estimates of all parameters in the model are tested at the same time. An advantage of structural equation modeling is that it allows the researcher to measure multiple independent and dependent variables in the same model (Tabachnik & Fidel, 2004). This approach accounts for a greater portion of error variance than other statistical techniques, such as regression, and allows

researchers to study latent variables rather than limiting analyses to observed variables.

SEM is considered a large sample test meaning that it requires a relatively large number of cases to achieve suitable statistical power. Kline (2011) suggests that researchers consider the absolute size of the sample, regardless of the number of parameters, and notes that SEM samples should include at least 200 cases. For maximum likelihood estimation, Jackson (2003) recommends an N:q rule, meaning that researchers should consider the ratio of the number cases (N) to number of parameters estimated in the model (q). Based on this, an ideal sample-size-to-parameter ratio is 20:1. However, ratios of 10:1 are acceptable. According to Kline (2011), results become less trustworthy as the N:q ratio drops below 10:1. My data set included 220 cases. To maximize statistical power when running models with numerous parameters, I aimed for an N:q ratio as close as possible to 10:1.

Interpretation of SEM models involves reporting several indices that measure how well a model fits the data. First, the chi-square is an absolute fit index meaning that the significance of chi-square shows how well the model reflects what is actually in the data. According to Hu and Bentler (1999), chi-square "assesses the magnitude of the discrepancy between the sample and the fitted covariance matrices" (p. 2). Because a significant *p-value* indicates that the sample and the fitted covariance matrices are significantly *different*, the model is a good fit if the chi-square statistic is > .05 (non-significant). However, the chi-square value may be an unreliable indicator of model fit because it is sensitive to sample size (larger sample sizes are more likely

to net significant results). Second, I will report the comparative fit index (CFI), which is commonly used because it is more resistant to effects of sample size than some of the other tests (e.g., goodness of fit) (Maruyama, 1998). Its values range from 0 to 1.0, and numbers greater than or equal to 0.95 indicate good fit (Hu & Bentler, 1999). Third, I will use the root mean square error of approximation (RMSEA), which determines how well the model fits the population covariance matrix (Hu & Bentler, 1999). One advantage of the RMSEA is that a confidence interval (AMOS utilizes a 90% confidence interval) is constructed around its value, which allows fit to be determined more precisely. The RMSEA values range from 0 to 1.0. Values between 0.10 and 0.07 indicate mediocre fit and values less than 0.07 indicate good fit. Finally, I will report the standardized root mean square residual (SRMR), which is the square root of the residuals between the sample covariance matrix and the hypothesized covariance matrix (Hu & Bentler, 1999). SRMR measures the residuals that are left over after a model has been fitted, thus reflecting variance from external influences the model did not capture. Models with a large number of parameters and large sample sizes will tend to have a value of SRMR closer to 0 (perfect fit); values less than or equal to 0.08 are also considered to be acceptable.

Hypothesis 3a predicted that a crew's level of *task interdependence* would predict *safety communication, psychological safety, failure learning, value of AARs,* and *AAR frequency.* This model (see Figure 3) was shown to be a poor fit for the data, $\chi^2(430) = 1091.67$, $p < .001$; *CFI* = .77; *RMSEA* = .08; *SRMR* = .08. The root mean square error of approximation (*RMSEA*) exceeded the acceptable level of .07 or

below. The standardized root mean square residual (*SRMR*) exceeded an acceptable level of *SRMR* < .05. Finally, a low value for *CFI* further indicated a poor fit as it was far below a value of .95 or greater.

To improve the model, I attempted several other versions of the model. I tested models that individually removed paths from *task interdependence* and the various theorized dependent variables. Each of these models proved to be a worse fit for the data. For example, when *failure learning* was removed from the model, $\chi^2(431) = 1325.29$, $p < .000$; *CFI* = .687; *RMSEA* = .097; *SRMR* = .088. In the next model, I replaced the path to *failure learning* but removed the path from *task interdependence* and *AAR frequency*. Although this model was a slight improvement, the model was a very poor fit, $\chi^2(431) = 1103.535$, $p < .000$; *CFI* = .765; *RMSEA* = .084; *SRMR* = .086. Similarly, I tested models that removed paths from *value of AARs, safety communication*, and *psychological safety*. All were a bit worse fit than the first model that included all the variables.

Even though the model as a whole was not significant, there were several noteworthy significant relationships between variables. First, the observed variables comprising task interdependence were related to the latent variable only moderately (see Table 8). This finding indicated that there was only a moderate amount of agreement that the items in the *task interdependence* latent construct were measuring the same phenomena. However, task interdependence, as a latent construct, was a strong predictor for safety communication ($\beta = .95$, $p < .001$) and failure learning ($\beta = .93$, $p < .001$), indicating that the observed measures in the construct, taken together,

strongly predicted the kinds of behaviors that comprised safety communication and failure learning. Third, the weakest relationship between the predictor and criterion variables was between task interdependence and AAR frequency ($\beta = .24$, $p < .001$). This finding suggested that AARs were not an inherent part of wildland firefighting work, but instead were a deliberate practice that might not be uniformly adopted across the organization. Even though the model as a whole was a poor fit for the data, the individual relationships comprising it indicate that task interdependence moderately to strongly predicted two of the outcome variables.

Hypothesis 3b predicted that a crew's level of *independence* would predict *safety communication, psychological safety, failure learning, value of AARs,* and *AAR frequency.* Results for the model (see Figure 4) were as follows, $\chi^2(401) = 1075.59$, $p < .001$; *CFI* = .76; *RMSEA* = .09; *SRMR* = .09. These indices showed that the model was a poor fit for the data.

As with H3a, I attempted to improve the model, I tried several other versions of the model. I tested models that individually removed paths between *independence* and the various theorized dependent variables. These models were a worse fit for the data. For example, when *failure learning* was removed from the model, $\chi^2(402) = 1377.712$, $p < .000$; *CFI* = .648; *RMSEA* = .105; *SRMR* = .093. In the next model, I replaced the path to *failure learning* but removed the path from *task interdependence* to *AAR frequency*. Again this model was a slight improvement, but the model was a very poor fit, $\chi^2(402) = 108.505$, $p < .000$; *CFI* = .756; *RMSEA* = .088; *SRMR* = .086. This modification was worse than the original model. As before, I tested models that

removed paths from *value of AARs, safety communication*, and *psychological safety*. All were a bit worse fit than the first model that included all the variables.

The model for H3b revealed that independence did not significantly predict any of the outcome variables (see Table 9). Further, the observed variables comprising independence were not significantly related to the latent construct. This points to a few potential problems with the items. First, lack of agreement among items in the scale might indicate that participants interpreted the items to have different meanings. For example, some firefighters might have interpreted the item, "members of this crew tend to be self-reliant rather than depend on others," as referring to a specific crew attitude related to their approach toward work (which is what the item was intended to measure), while other firefighters might have understood the item to be referring to a broader attitude about how they approach life in general (an attitude that does not capture the crew's unique climate). Second, and related, independence might have been associated with different activities that the items perhaps mis-specified. For example, the remaining two items on the scale referred to members' abilities to 1) "act" independently and 2) to "work" independently. In the wildland fire context, "acting" and "working" might refer to different sets of actions, which would have decreased the strength and significance of their relationship with the latent variable.

H3a and H3b were designed to be compared side-by-side to examine how task interdependence and independence affected crew activities and the interaction environment. Both of the models showed poor fit indicating that neither task

interdependence nor independence were strong enough predictors by themselves to significantly influence a crew's safety communication, psychological safety, failure learning, or value or frequency of AARs. However, when examining the significance of individual relationships that comprised each model, the findings suggested that task interdependence was a strong predictor for communication behaviors in general, while independence was not a significant predictor for any of the communication behaviors. Importantly, independence was not a negative predictor for the dependent variables, which suggested that level of independence, while not enabling communication behaviors, did not appear to obstruct them. This finding provided potential evidence that task interdependence and independence were not opposite notions in the wildland firefighting context; instead, the concepts captured different sets of activities and attitudes. Finally, these findings should be interpreted with caution because both models included inadequate sample-size-to-parameter (N:q) ratios. Klein (2011) recommends N:q ratios be as close as possible to 10:1 for trustworthy results, yet H3a and H3b ratios were approximately 0.51: 1.

Hypothesis 4 stated that high independence and low task interdependence predicted high social work-safety tension. A regression analysis tested the relationship and was significant $F(2, 217) = 7.57$, $p < .01$; $r = .26$, $R^2 = .07$. Only *independence* was found to be a significant predictor of *social work safety tension* ($\beta = -.24$, $p < .001$). However, the relationship was in the opposite direction than predicted, indicating that higher levels of independence predicted lower levels of social work-safety tension. Task interdependence was not a significant predictor ($\beta =$

-.02, $p = .87$). These findings revealed that a crew's level of independence was a relatively strong predictor of whether members felt social pressure to engage in hazardous activities—such that the more independent members were, the less social pressure they would feel to engage hazards at the expense of safety.

Taken together, findings related to RQ2 indicated that independence and task interdependence address two distinct aspects of crew life. First, there appeared to be a baseline of task interdependence across the organization (H2b), while independence was more widely varied (H2a). To more closely examine this relationship, I ran a post-hoc, paired samples t-test comparing the means of task interdependence and independence; it was significant: $t(219) = -12.20$, $p < .001$. This result confirmed that levels of task interdependence ($M = 1.98$, $SD = .69$) were generally higher and less varied across the organization than levels of independence ($M = 2.93$, $SD = 1.02$).

Second, neither task interdependence nor independence were significant predictors on a crew's communication activities or its psychological safety (H3a, H3b). Third, high levels of independence were a significant, moderate predictor for low levels of social work-safety tension (H4). In that same regression model, task interdependence did not significantly contribute to the level of social work-safety tension. This finding further supported the idea that independence was more novel than task interdependence across wildland firefighting. Further, the importance of high independence levels on facilitating low social work safety tension suggested that independent action was associated with members feeling a greater amount of control over their circumstances, and thus being more resistant to social pressures to take

risks. Because task interdependence was not a significant predictor of social work safety tension, it can be concluded that there was nothing particularly noteworthy about coordinating on tasks that would enable members to feel they can resist social pressures to engage hazards. The following research question further examined the social environment. It explored how variables related to communication activities and the interaction environment related to one another.

RQ3: How do crew communication activities (safety communication, failure learning, AAR frequency and value) relate to aspects of the crew interaction environment (crew prestige, psychological safety, work-safety tension)?

Research question three focused specifically on the interplay among communication-based activities and the feel of the crew interaction environment. This research question reflected the basic premise found throughout the safety climate literature that climate and action are recursively related. Therefore, the feel of the social environment influences whether members engage in safety-related action, and safety actions shape the feel of the crew's social climate. The hypotheses pertaining to this research question test which variables have more and less influence on each other, and how (see Table 10).

Hypothesis 5 stated that crews' high safety communication, failure learning behaviors, psychological safety, and frequency and value of after action reviews (AARs) would predict low *social work-safety tension*. A regression analysis was conducted in which the dependent variable, social work-safety tension was regressed

on the five predictor variables. The model was significant $F(5, 214) = 8.49$, $p < .001$; $r = .41$, $R^2 = .17$ with the predictor variables accounting for 17% of the variance in social work safety tension. However, only safety communication ($\beta = -.54$, $p < .001$) was a significant predictor. Safety communication measured how freely members felt they could bring up safety concerns to their peers and supervisors. Compared to the other variables in the regression equation, safety communication addressed the most basic safety actions, whereas failure learning and AARs were more deliberate, retrospective safety activities. Thus, being able to freely address safety concerns in-the-moment (i.e., safety communication) significantly and strongly predicted a lower degree of pressure to accept hazards. The next hypothesis addresses crew characteristics influencing a crew's level of safety communication.

Hypothesis 6 stated that crew prestige, task interdependence and independence predicted safety communication. A regression analysis was conducted and the regression equation, including the three variables on safety communication, was found to be significant $F(3, 216) = 21.09$, $p < .001$; $r = .48$, $R^2 = .23$. The regression equation indicated that 23% of the variance in safety communication was accounted for by the three variables. Each variable was a significant predictor of safety communication as follows, independence ($\beta = .09$, $p < .05$), crew prestige ($\beta = .36$, $p < .001$), and task interdependence ($\beta = .19$, $p < .01$).

It was unexpected that crew prestige was the strongest predictor of safety communication. Items in crew prestige measured the degree to which a crew was highly regarded both by members and within the firefighting community. This

finding can be interpreted to mean that freedom to voice safety concerns upwardly and in general (i.e., safety communication) among the crew was a characteristic that was highly regarded in wildland firefighting. This might indicate that firefighters across the profession accept safety-related communication activities within their crews. This finding might also indicated that firefighters prefer safety conscious behaviors (as opposed to bold or risky actions). Further, for members to consider their group to be prestigious, they must think highly of the collective, including the ways the crew accomplishes work, the degree to which it upheld high standards, and believing that membership on the crew was sought-after within firefighting. Taking all three significant relationships of the regression together, the results indicated that having standards that members were proud of, combined with interconnected tasks in which communicative exchange was ongoing enhanced safety communication. Some level of independence also was important because it likely indicated members' abilities and comfort with expressing concerns or original thought without feeling intimidated. The next hypothesis directed attention toward the factors that contributed to a crew's psychological safety, which refers to the degree to which a crew is a safe place for interpersonal risk taking (Edmondson, 1999).

Hypothesis 7 stated that high crew prestige, safety communication, failure learning, AAR value and AAR frequency predicted high crew psychological safety. A regression analysis including all five variables on psychological safety, was conducted and the regression equation was found to be significant $F(5, 214) = 54.02$, $p < .001$; $r = .75$, $R^2 = .56$. The regression equation indicated that 56% of the variance

in psychological safety was accounted for by the five variables. Three of the five predictor variables were found to have significant effects on psychological safety, including crew prestige ($\beta = .17$, $p < .01$), safety communication ($\beta = .39$, $p < .001$) and failure learning ($\beta = .32$, $p < .001$).

It made sense that safety communication and failure learning were such heavily-weighted predictors of psychological safety. This can be interpreted to mean that the more freely members felt they were able to raise safety concerns to supervisors and other crew members (safety communication), and the presence of communication practices specifically related to learning from failure (failure learning) would make members more comfortable (and perhaps even set expectations for members) to communicate openly. The result of communication practices and openness was that they help members to feel safe in expressing concerns and insights. Also, the finding that crew prestige was a significant predictor of psychological safety made sense because the higher collective esteem about the crew, the more members might have value their contributions and wanted to share them, leading to higher psychological safety.

It was not surprising that AAR frequency and AAR value were not significant predictors in the regression equation. Even though AARs were considered to be a standard practice across wildland firefighting, there might have been wide variation across crews in how they were used and valued. The next hypothesis investigated elements that predicted crew prestige.

Hypothesis 8 stated that failure learning behaviors, safety communication, AAR value, AAR frequency, independence and task interdependence predicted crew prestige. A regression analysis included the six variables on crew prestige, and was found to be significant $F(6, 213) = 18.77$, $p < .001$; $r = .59$, $R^2 = .35$. The regression equation indicated that 35% of the variance in crew prestige was accounted for in the model, however, only task interdependence ($\beta = .27$, $p < .001$) and failure learning ($\beta = .30$, $p < .001$) were significant predictors of crew prestige.

This hypothesis evaluated factors that contributed to a crew's positive reputation within the wildland firefighting community. The basis for this hypothesis was that crews would be considered well-regarded in the firefighting community based in large part on the ways their crew operated, specifically their communication activities and work styles (independence, task interdependence). Two related issues emerged: First, this finding showed that crew prestige was strongly shaped by the extent to which members depended on coordinating with one another on tasks (task interdependence). Through coordination, members saw themselves as a collective. Second, failure learning activities were a strong predictor of crew prestige. Failure learning activities required deliberate effort, as opposed to spontaneous communication. Crews that made the effort to engage in learning-based communication were likely invested in benefitting the collective group. Task interdependence and failure learning both pointed to concern for the crew as a collective unit. Thus, well-regarded crews were those that engaged in activities that

bound members together (task interdependence) while also making deliberate efforts to help members learn (failure learning).

Based on the idea that crew prestige played a central role in defining the crew environment, the next hypotheses tested how crew prestige was related to pressure to accept hazards.

Hypothesis 9a stated that high crew prestige predicted high *social work-safety tension*. A regression analysis testing this hypothesis was significant at $F(1, 217) = 8.95$, $p < .01$; $r = 20$; $R^2 = .04$; $\beta = -.28$, $p <. 01$. Fluctuation in crew prestige accounted for 4 percent of the variance in work safety tension. The more prestigious a crew considered itself to be, the less pressure members felt to implement hazardous tasks at the expense of providing safety measures. This finding was opposite from the relationship hypothesized. However, in retrospect this relationship was not surprising considering the results from the previous hypothesis (H8), which found that crew prestige was shaped by factors that seemed to privilege the well being of the collective crew. A prestigious crew was one in which members were highly interconnected and in which members made deliberate efforts to engage in failure learning. Thus, prestigious crews were those that were concerned with their members' safety, and lower social pressure to engage in hazards was expected.

Because there were varying levels of independence and task interdependence across the organization, I tested whether either of those variables moderated the relationship between crew prestige and social work-safety tension. The results are presented next.

Hypothesis 9b predicted that crew *task interdependence* moderated the relationship between *crew prestige* and *social work-safety tension* (see Figure 5). This moderated relationship was a poor fit for the data: $\chi^2(88) = 226.3$, $p < .001$; *CFI* = .85; *RMSEA* = .09; *SRMR* = .0744. These results indicate that the model was a poor fit for the data. Based on the beta weights of the paths depicted in Figure 5, crew prestige was a strong predictor for task interdependence, while task interdependence did not significantly predict lower social work-safety tension (see Table 11).

Hypothesis 9c predicted that crew *independence* moderated the relationship between *crew prestige* and *social work-safety tension* (see Figure 6). This moderated relationship was a poor fit of the data: $\chi^2(401) = 1075.59$, $p < .001$; *CFI* = .76; *RMSEA* = .09; *SRMR* = .09. Table 12 shows that crew prestige was not a significant predictor for independence, but that independence had a significant and negative influence on social work safety tension, such that crews that reported high independence reported low social work-safety tension.

To synthesize H9a, H9b and H9c, the relationship between crew prestige and social work-safety tension was opposite than predicted such that high crew prestige predicted low social work safety tension. High independence levels also predicted low social work-safety tension while task interdependence had no influence on the dependent variable. This revealed that members felt less pressure to engage in unsafe work when they felt free to act independently, or if their crew was highly prestigious. Prestige seemed to relate to sense of concern for the collective such that prestigious crews were those whose members were aware that there was collective concern for

acting safely. Independence appeared to relate to an individual's sense of control over avoiding being drawn into group activities he or she felt no control over.

To further explore the relationships among safety climate variables, and based on the findings from the present research question, I fitted a structural equation model that approached significance (Model 10a, Figure 7): $\chi^2(2) = 7.81$, $p = .02$; *CFI* = .99; *RMSEA* = .12; *SRMR* = .03. Indices show that the model is overall a good fit for the data, but it lacks parsimony due to a value of *RMSEA* that is higher than .1. I reviewed the regression weights of the individual paths in the model and found that the path from task interdependence to crew prestige was weak and not significant ($\beta = -.05$, $p = .83$) (Table 13). However, the relationship between those same variables was moderately strong and significant in the opposite direction, from crew prestige to task interdependence ($\beta = .43$, $p < .05$). I decided to delete the path from task interdependence to crew prestige. This made theoretical sense because, in another hypothesis test, I found that task interdependence acted as a moderating variable between crew prestige and social work-safety tension (H9b). Similarly for this model, I considered task interdependence to be a moderator between crew prestige and safety communication.

The modified model (Model 10b, Figure 8) was a good fit for the data $\chi^2(3) = 7.86$, $p = .05$; *CFI* = .99; *RMSEA* = .09; *SRMR* = .03, and all regression paths were significant (Table 14). This model showed several important relationships and how these constructs worked together in crew interaction. First, safety communication ($\beta = .61$, $p < .001$) was a strong predictor for failure learning behaviors. Previous

hypothesis tests suggested that safety communication referred to in-the-moment communication behaviors while failure learning referred to a more deliberate retrospective learning activity. Second, safety communication ($\beta = .44$, $p < .001$) was a stronger predictor for psychological safety than was failure learning ($\beta = .34$, $p < .001$), which suggested that the degree to which members feel comfortable for interpersonal risk taking on the crew was more strongly influenced by their ability to voice concerns in-the-moment (safety communication) than it was by whether their crew deliberately engaged in learning activities (failure learning). Third, psychological safety moderately and significantly predicted crew prestige ($\beta = .35$, $p < .001$) indicating that highly reputable crews were those whose members felt comfortable interacting with one another. Finally, crew prestige predicted whether the crew engaged in failure learning activities ($\beta = .21$, $p < .001$), as well as the degree to which a crew was rated as task interdependent (($\beta = .39$, $p < .001$). Task interdependence acted as a moderator between crew prestige and safety communication such that a greater degree of task interdependence predicted higher safety communication ($\beta = .27$, $p < .001$).

To summarize research question three, H5 found that members' ability to speak openly and in-the-moment about safety (safety communication) was a powerful predictor of the crew's psychological safety. Exploring the conditions that enabled safety communication, H6 found that crew prestige was the strongest among several predictors for safety communication, followed by task interdependence and independence. This finding revealed the unexpected importance of crew prestige in

shaping the workgroup's safety climate and interaction dynamics. Further exploring crew prestige as a central predictor for engaging in communication-based learning activities, H8 investigated which factors contributed to it. Findings revealed that crew prestige was most closely tied to task interdependence and failure learning behaviors. These findings suggested that crew prestige is closely associated with a sense of crew collectiveness and an atmosphere that deliberately promoted member learning.

In this section, I have presented findings from three research questions aimed at revealing how staffing, work styles, communication activities, and interaction environment interrelate to influence safety climate in wildland firefighting crews. The next section discusses important findings and how they relate to wildland firefighting workgroup, safety climate and high reliability organizing.

Summary

This section summarizes the key findings from Study Two. A fuller discussion of the implications of these findings and how they relate to Study One and high reliability organizing is included in Chapter 6.

Research Question 1: Co-located versus Dispersed Staffing Patterns

The findings revealed that co-located crews and dispersed crews differed as would be expected with co-located crews showing significantly higher task interdependency and significantly lower independence than dispersed crews. However, it was notable that co-located and dispersed crews did not differ significantly on any of the interaction environment or communication activity

variables. This finding suggested that staffing patterns might play a less important role in the safety climate than indicated in Study One.

Research Question 2: Task Interdependent and Independent Work Styles

The findings strongly indicated that task interdependence and independence are not, in fact, opposite measures. Instead, these concepts appeared to capture different types of activities in the wildland firefighting context. Task interdependency appeared to assess basic aspects of firefighting work—it was a comfortable constant for members. Firefighting tasks tend to be large scale and requiring coordination among numerous resources. Therefore, a measure of task interdependence in this context may only describe the nature of the work, rather than indicating anything distinctive about how particular crews operated. In contrast, opportunities to work independently seemed to be more novel. Hypothesis 5a revealed that specialty areas varied widely on independence, while they did not vary much on task interdependence (H2b). Further, high independence was a moderately strong predictor for low social work safety tension (H4). This suggested that crews in which members were accustomed to making their own decisions might have trusted themselves more and as a result might have been more resistant to the influences of the group regarding taking risks.

Even though task interdependence seemed to be a description of what was required for firefighting work tasks in general, there were some relationships in which it played a substantial role. Specifically, task interdependence was a significant and strong predictor (along with failure learning activities) of crew prestige (H8).

From the importance of task interdependence in that regression equation, it can be inferred that the degree to which members felt it was necessary to work together on tasks might have boosted their feelings that their collaborations were necessary to produce high-quality work. This, in turn, might have enhanced their evaluation of the quality of the crew (its prestige). In contrast, working independently might not have cued members to feel that collective effort was useful, and as a result, might not be an important contributor to members valuing the quality and reputation of the workgroup's efforts. A strong sense of task interdependence might cue an awareness of the collective crew, which may cause firefighters to consider more conservative actions regarding hazards because they are more aware of the safety implications for their entire crew.

Taken together, independence seemed to describe how a crew went about conducting work, while task interdependence tended to describe the kinds of responses required for the large-scale coordination-intensive tasks involved in wildland firefighting. Also, crew specialties tend to vary from one another on several of their duties, which might have contributed to their varying levels of independence. For example, helitack/rappel crews manage aircraft missions that require members to staff various helicopter landing and cargo sites dispersed across the geographic area of a fire. Hotshot and Type 2 hand crews each tended to work together as single units. Engine crews typically had small modules of three to seven members, and with so few people to manage (in comparison to a hotshot or Type 2 hand crew which typically staff 20 members), the unit might operate with a great deal of autonomy.

However, task interdependence was a significant predictor of crew prestige (H8) which suggested that, in the wildland fire context, it played a strong and pointed role in contributing to crew prestige (above and beyond simply being descriptive of the type of coordination required for wildland firefighting tasks). Perhaps task interdependence could address the nature of tasks on one hand and also the characteristic organizing style of the workgroup on the other.

Basic Safety versus Intentional Climate

The findings draw a clear distinction between minimal conditions for members to act safely, and deliberate activities designed to enhance learning and comfort of the collective crew environment.

Basic safety. Minimal conditions for safe action were indicated in H5, which revealed that out of several constructs including safety communication, failure learning, psychological safety, and frequency and value of AARs, only safety communication had a significant and strong influence on reducing social work-safety tension. It was initially surprising that failure learning behaviors and psychological safety did not have significant effects on social work safety tension. Examining the items that comprise safety communication, AAR value, failure learning, and psychological safety, it appeared that safety communication captured the basic and necessary conditions for safety on the crew such that safety communication partially diffused pressure to engage in hazardous activities. To contrast, failure learning and psychological safety seemed to measure other aspects of crew life such as the degree to which a crew was cohesive or got along. Those aspects might not be directly

related to work safety tension. An alternative explanation for these results could be that members felt social pressure to engage in unsafe behaviors, even though they knew they would talk about them later. Thus, regardless of failure communication, firefighters still felt pressure to engage hazardous situations.

Intentional climate. Psychological safety measured the degree to which the workgroup environment felt safe for interpersonal risk-taking. This type of crew environment is likely important in wildland firefighting because firefighters face ambiguous fireline circumstances in which it is difficult to discern and prioritize hazards. It can be difficult for a firefighter to know if what he or she is seeing warrants the concern of others, and members may fear social costs associated with bringing up insignificant concerns. Having strong safety communication and failure learning practices in place appeared to facilitate an environment in which there were fewer social costs associated with expressing concerns and participating in learning, particularly learning from mistakes. In this case, safety communication can be considered a necessary condition that enables failure learning activities to occur, meaning that failure learning activities would not likely occur without there also being safety communication, but safety communication can be present even when failure learning activities are not.

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[11] This result might be due to two factors: First, there was a low response rate from Type 2 crews overall. Second, there is not a standard definition for what constitutes a Type 2 crew. It sometimes refers to an established crew, but also is a catch-all category referring to any collection of minimally qualified firefighters, including resource or recreation personnel, fuels reduction crews, and ad hoc crews assembled for the purpose of a single fire assignment.

Table 6

Research Question 1 Hypothesis and Results

Hypothesis	Findings
RQ1: How does crew *staffing pattern* relate to *work style*, crew *communication activities* and aspects of the *crew interaction* environment?	
H1: Co-located crews will significantly differ from dispersed crews, reporting lower independence,* and higher task interdependence,* safety communication, psychological safety, failure-based learning behaviors and AAR frequency.	$F(6, 213) = .895$, $p < .001$ Independence: $F(1, 218) = 8.01$, $p < .01$ Co-located ($M = 3.03$, $SD = .99$) Dispersed ($M = 2.54$, $SD = 1.04$); Task Interdependence: $F(1, 218) = 11.92$, $p < .01$ Co-located ($M = 1.91$, $SD = .66$) Dispersed ($M = 2.30$, $SD = .75$)

* = Significant in predicted direction.
Staffing patterns = Co-located, dispersed.
Work style = Independent, task interdependent.
Communication activities = Safety communication, failure learning, AAR frequency, AAR value.
Interaction environment = Psychological safety, crew prestige, social work safety tension.

Table 7

Research Question 2 Hypotheses and Results

Hypothesis	Findings
RQ2: How are independence and task interdependence related to each other in wildland firefighting? How do independence and task interdependence compare to each other in their influence on workgroup safety climate?	
H2a: Specialty areas will differ in their levels of independence.	$F(3, 216) = 9.75$, $p < .001$
H2b: Specialty areas will differ in their levels of task interdependence.	$F(3, 216) = 4.36$, $p < .01$
H3a: Crew task interdependence predicts safety communication, psychological safety, failure-based learning behaviors and frequency and value of AARs.	$\chi^2(430) = 1091.67$, $p < .001$; $CFI = .77$; $RMSEA = .08$; $SRMR = .08$
H3b: Crew independence predicts safety communication, psychological safety, failure-based learning behaviors and frequency and value of AARs.	$\chi^2(401) = 1075.59$, $p < .001$; $CFI = .76$; $RMSEA = .09$; $SRMR = .09$
H4: High independence** and low task interdependence predict high social work-safety tension.	$F(2, 217) = 7.57$, $p < .01$, $r = .26$, $R^2 = .07$ Independence ($\beta = -.24$, $p < .001$) Task Interdependence ($\beta = -.02$, $p = .87$)

* = Significant in predicted direction.
** = Significant in opposite direction than predicted.

Table 8

Model H3a Standardized Regression Weights

$\chi^2(430) = 1091.67$, $p < .001$; *CFI* = .77; *RMSEA* = .08; *SRMR* = .08.

			β	Sig.
Safety Comm	<---	Task Interdependence	.950	***
Psych Safety	<---	Task Interdependence	1.004	***
Failure Learning	<---	Task Interdependence	.933	***
AAR Value	<---	Task Interdependence	.570	***
TI_WRK_CLOSE	<---	Task Interdependence	.489	
TI_COORD	<---	Task Interdependence	.337	***
TI_SHAREINFO	<---	Task Interdependence	.417	***
SC_S_SAFE_ISSUES	<---	Safety Comm	.663	
SC_S_ACCPT_IDEAS	<---	Safety Comm	.413	***
SC_S_OPEN_COMM	<---	Safety Comm	.744	***
SCrv_QUESTN_S	<---	Safety Comm	.511	***
SCrv_S_RELUCTANT	<---	Safety Comm	.433	***
SCrv_S_AVOID	<---	Safety Comm	.543	***
SCrv_HIGHER_RNK	<---	Safety Comm	.398	***
PS_PROBS_ISSUES	<---	Psych Safety	.716	
PS_SKLS_VALUED	<---	Psych Safety	.464	***
PSrv_MISTAK_HELD	<---	Psych Safety	.515	***
PSrv_REJECT_DIFF	<---	Psych Safety	.411	***
PSrv_ASK4HELP	<---	Psych Safety	.491	***
FL_MISTAK_LRN	<---	Failure Learning	.519	
FL_OWN_MISTAKE	<---	Failure Learning	.578	***
FL_WHY_DO_WE	<---	Failure Learning	.682	***
FL_A_BETTER_WAY	<---	Failure Learning	.692	***
FL_STOP2TALK	<---	Failure Learning	.621	***
FL_QUESTN_RSNS	<---	Failure Learning	.826	***
FL_TALK_OPNLY	<---	Failure Learning	.792	***
FL_UNDRSND_RSNS	<---	Failure Learning	.762	***
AAR5rv_NOT_NECRY	<---	AAR Value	.701	***
AAR_FREQ	<---	Task Interdependence	.243	.001
AAR_FREQ	<---	e1	.970	***
TI_CONSULT	<---	Task Interdependence	.281	***
AAR4_USEFUL	<---	AAR Value	.882	***
AAR3_IMPTNT	<---	AAR Value	.726	***
AAR2_PARTIC	<---	AAR Value	.612	***
AAR1_VALUE	<---	AAR Value	.882	
SCrv_EARN_RIGHT	<---	Safety Comm	.341	***

Table 9

H3b Standardized Regression Weights

$\chi^2(401) = 1075.59$, $p < .001$; *CFI* = .76; *RMSEA* = .09; *SRMR* = .09.

			β	Sig.
Failure Learning	<---	Independence	.937	.131
AAR Value	<---	Independence	.549	.132
Safety Comm	<---	Independence	.962	.129
Psych Safety	<---	Independence	1.010	.127
SC_S_SAFE_ISSUES	<---	Safety Comm	.654	
SC_S_ACCPT_IDEAS	<---	Safety Comm	.405	***
SC_S_OPEN_COMM	<---	Safety Comm	.739	***
SCrv_QUESTN_S	<---	Safety Comm	.513	***
SCrv_S_RELUCTANT	<---	Safety Comm	.437	***
SCrv_S_AVOID	<---	Safety Comm	.548	***
SCrv_HIGHER_RNK	<---	Safety Comm	.417	***
PS_PROBS_ISSUES	<---	Psych Safety	.710	
PS_SKLS_VALUED	<---	Psych Safety	.454	***
PSrv_MISTAK_HELD	<---	Psych Safety	.529	***
PSrv_REJECT_DIFF	<---	Psych Safety	.418	***
PSrv_ASK4HELP	<---	Psych Safety	.490	***
FL_MISTAK_LRN	<---	Failure Learning	.528	
FL_OWN_MISTAKE	<---	Failure Learning	.577	***
FL_WHY_DO_WE	<---	Failure Learning	.690	***
FL_A_BETTER_WAY	<---	Failure Learning	.705	***
FL_STOP2TALK	<---	Failure Learning	.616	***
FL_QUESTN_RSNS	<---	Failure Learning	.831	***
FL_TALK_OPNLY	<---	Failure Learning	.781	***
FL_UNDRSND_RSNS	<---	Failure Learning	.751	***
AAR5rv_NOT_NECRY	<---	AAR Value	.703	***
AAR_FREQ	<---	Independence	.242	.160
AAR_FREQ	<---	e1	.970	***
AAR4_USEFUL	<---	AAR Value	.881	***
AAR3_IMPTNT	<---	AAR Value	.725	***
AAR2_PARTIC	<---	AAR Value	.611	***
AAR1_VALUE	<---	AAR Value	.883	
SCrv_EARN_RIGHT	<---	Safety Comm	.351	***
INDEP_SELF_REL	<---	Independence	.109	
INDEP_ACT_INDP	<---	Independence	.243	.160
INDEP_WRK_INDP	<---	Independence	.141	.224

Table 10

Research Question 3 Hypotheses and Results

Hypothesis	Findings
RQ3: How do crew *communication activities* and aspects of the crew *interaction environment* inform a crew's safety climate?	
H5: High frequency and value of AARs, safety communication*, failure learning and psychological safety predict low social work safety tension.	$F(5, 214) = 8.49$, $p < .001$, $r = .41$, $R^2 = .17$ Safety communication ($\beta = -.54$, $p < .001$)
H6: High crew prestige,* task interdependence* and independence* predict high safety communication.	$F(3, 216) = 21.09$, $p < .001$, $r = .48$, $R^2 = .23$ Crew prestige ($\beta = .36$, $p < .001$) Task interdependence ($\beta = .19$, $p < .01$) Independence ($\beta = .09$, $p < .05$)
H7: High crew prestige,* safety communication,* failure-based learning,* AAR value and AAR frequency predict high psychological safety.	$F(5, 214) = 54.02$, $p <. 001$, $r = .75$, $R^2 = .56$ Crew prestige ($\beta = .17$, $p < .01$) Safety communication ($\beta = .39$, $p < .001$) Failure learning ($\beta = .32$, $p < .001$)
H8: High failure learning,* safety communication, AAR value and AAR frequency, task interdependence* and independence predict high crew prestige.	$F(6, 213) = 18.77$, $p < .001$, $r = .59$, $R^2 = .35$ Task interdependence ($\beta = .27$, $p < .001$) Failure learning ($\beta = .30$, $p < .001$)
H9a: High crew prestige is related to high social work-safety tension.**	$F(1, 217) = 8.95$, $p < .01$; $r = 20$; $R^2 = .04$; $\beta = -.28$, $p <. 01$
H9b: A crew's task interdependence moderates the relationship between crew prestige and social work safety tension.	$\chi^2(88) = 226.3$, $p < .001$; *CFI* = .85; *RMSEA* = .09; *SRMR* = .07
H9c: A crew's independence moderates the relationship between crew prestige and social work safety tension.	$\chi^2(75) = 179.5$, $p < .001$; *CFI* = .88; *RMSEA* = .08; *SRMR* = .08

* = Significant in predicted direction.
** = Significant in opposite direction than predicted.
Communication activities = safety communication, failure learning, AAR frequency, AAR value.
Interaction environment = psychological safety, crew prestige, social work safety tension

Table 11

H9b Standardized Regression Weights

$\chi^2(88) = 226.3$, $p < .001$; *CFI* = .85; *RMSEA* = .09; *SRMR* = .07

			β	Sig.
Task interdependence	<---	crew prestige	.581	***
social WST	<---	Task interdependence	-.131	.193
CPrv_LOOK_DWN	<---	crew prestige	.524	
CPrv_NOTWANT	<---	crew prestige	.578	***
CPrv_DWNPLAY	<---	crew prestige	.502	***
CPrv_REP	<---	crew prestige	.569	***
CP_BEST	<---	crew prestige	.783	***
CP_STANDARDS	<---	crew prestige	.547	***
CP_HIGH_VALU	<---	crew prestige	.709	***
CP_THNK_HIGH	<---	crew prestige	.864	***
WST_PRESSURE	<---	social WST	.686	
WST_DANGEROUS	<---	social WST	.610	***
WST_REWARDED	<---	social WST	.453	***
TI_WRK_CLOSE	<---	Task interdependence	.584	
TI_COORD	<---	Task interdependence	.681	***
TI_SHAREINFO	<---	Task interdependence	.545	***
TI_CONSULT	<---	Task interdependence	.597	***

Table 12

H9c Standardized Regression Weights

$\chi^2(75) = 179.5$, $p < .001$; *CFI* = .88; *RMSEA* = .08; *SRMR* = .08

			β	Sig.
independence	<---	crew prestige	.128	.127
social WST	<---	independence	-.422	***
CPrv_LOOK_DWN	<---	crew prestige	.526	
CPrv_NOTWANT	<---	crew prestige	.579	***
CPrv_DWNPLAY	<---	crew prestige	.503	***
CPrv_REP	<---	crew prestige	.575	***
CP_BEST	<---	crew prestige	.781	***
CP_STANDARDS	<---	crew prestige	.544	***
CP_HIGH_VALU	<---	crew prestige	.701	***
CP_THNK_HIGH	<---	crew prestige	.867	***
INDEP_WRK_INDP	<---	independence	.744	
INDEP_ACT_INDP	<---	independence	.704	***
INDEP_SELF_REL	<---	independence	.625	***
WST_PRESSURE	<---	social WST	.764	
WST_DANGEROUS	<---	social WST	.556	***
WST_REWARDED	<---	social WST	.419	***

Table 13

Model 10a Standardized Regression Weights

			β	Sig.
SC_FAC	<---	TI_FAC	.245	.003
FL_FAC	<---	CP_FAC	.197	***
FL_FAC	<---	SC_FAC	.627	***
PS_FAC	<---	FL_FAC	.325	***
PS_FAC	<---	SC_FAC	.425	***
CP_FAC	<---	PS_FAC	.397	***
TI_FAC	<---	CP_FAC	.434	.029
CP_FAC	<---	TI_FAC	-.048	.829

Table 14

Model 10b Standardized Regression Weights

			β	Sig.
SC_FAC	<---	TI_FAC	.255	***
FL_FAC	<---	CP_FAC	.197	***
FL_FAC	<---	SC_FAC	.627	***
PS_FAC	<---	FL_FAC	.325	***
PS_FAC	<---	SC_FAC	.426	***
CP_FAC	<---	PS_FAC	.386	***
TI_FAC	<---	CP_FAC	.393	***

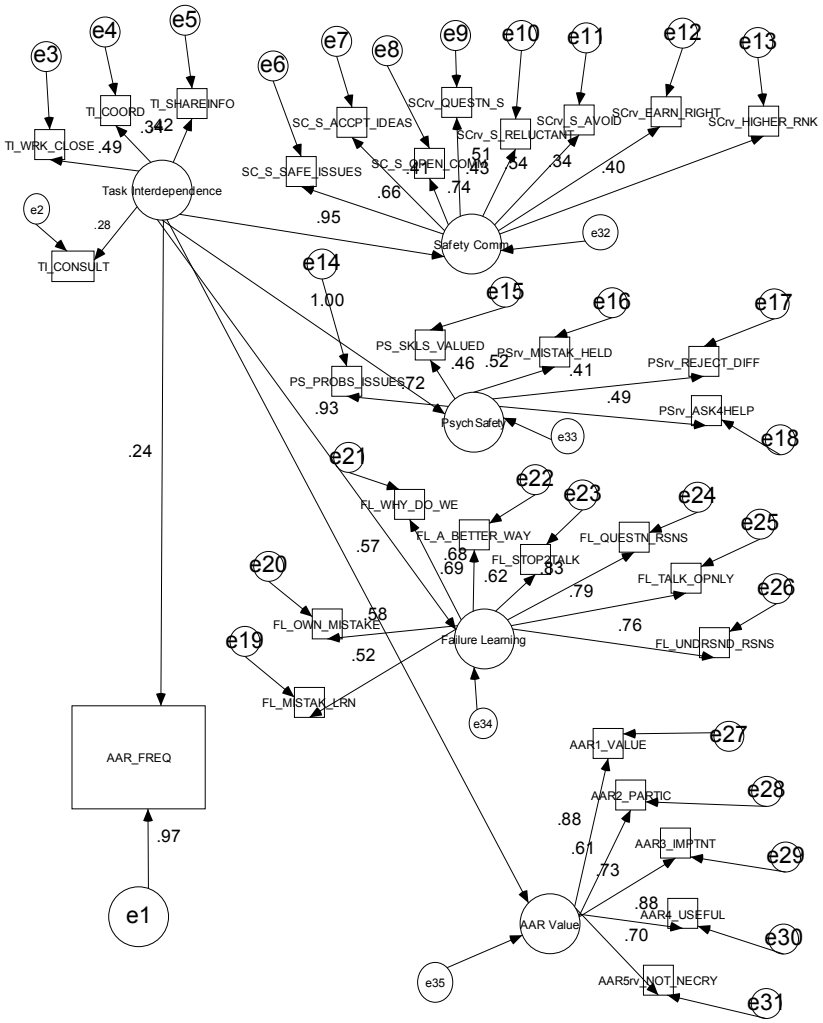

Figure 3. Model of H3a hypothesizing that crew task interdependence predicts safety communication, psychological safety, failure learning, value of AARs and AAR frequency.

$\chi^2(430) = 1091.67$, $p < .001$; *CFI* = .77; *RMSEA* = .08; *SRMR* = .08.

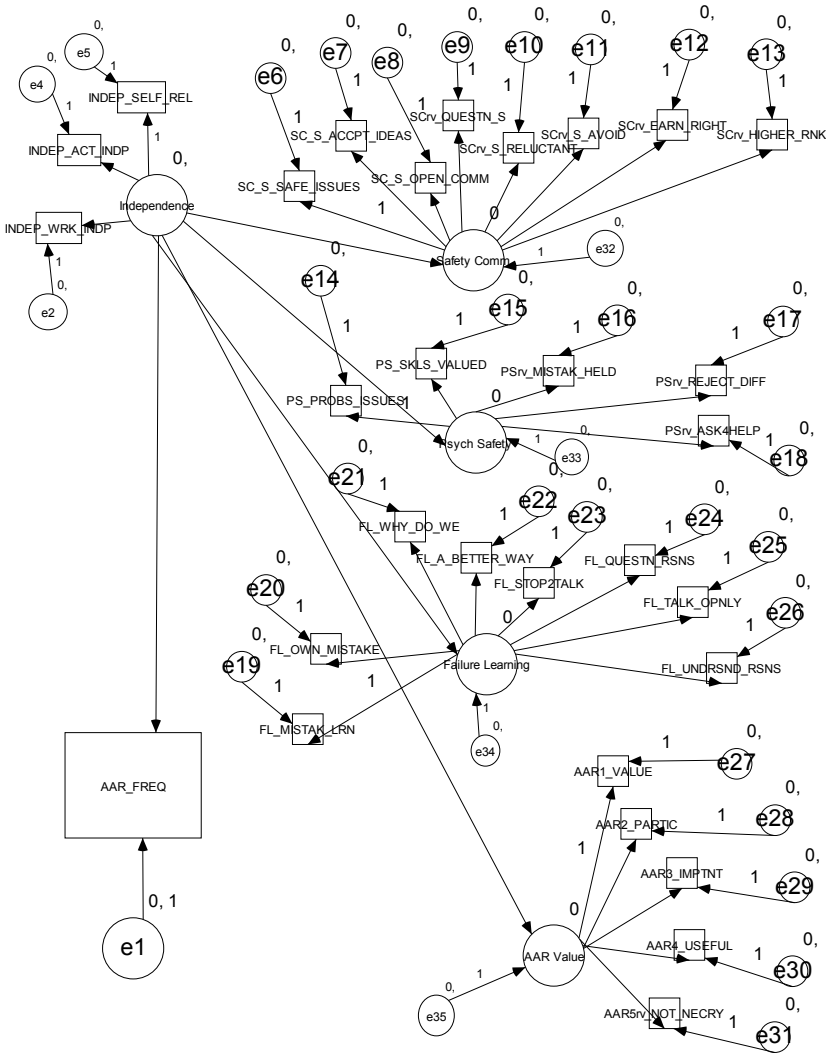

Figure 4. Model of H3b hypothesizing that crew independence predicts safety communication, psychological safety, failure learning, value of AARs and AAR frequency.

$\chi^2(401) = 1075.59$, $p < .001$; *CFI* = .76; *RMSEA* = .09; *SRMR* = .09.

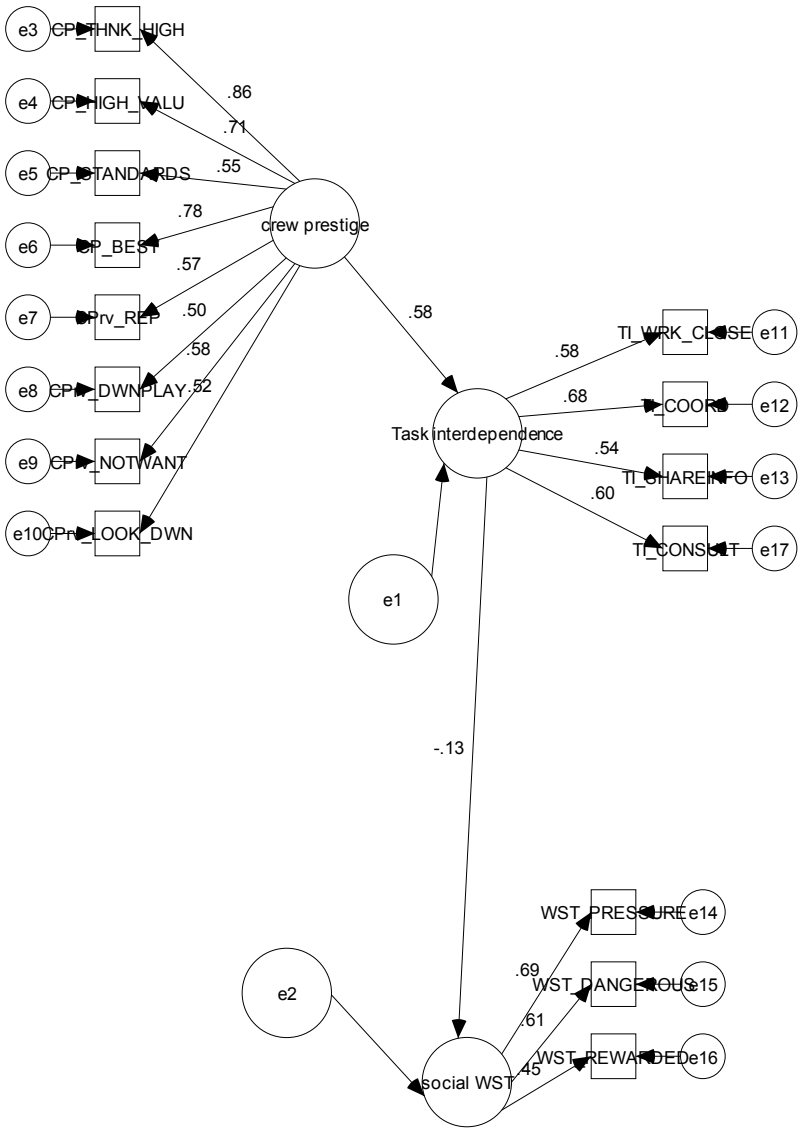

Figure 5. Model of H9b predicting that a crew's level of task interdependence moderates the relationship between crew prestige and work safety tension. $\chi^2(88) = 226.3$, $p < .001$; *CFI* = .85; *RMSEA* = .09; *SRMR* = .07.

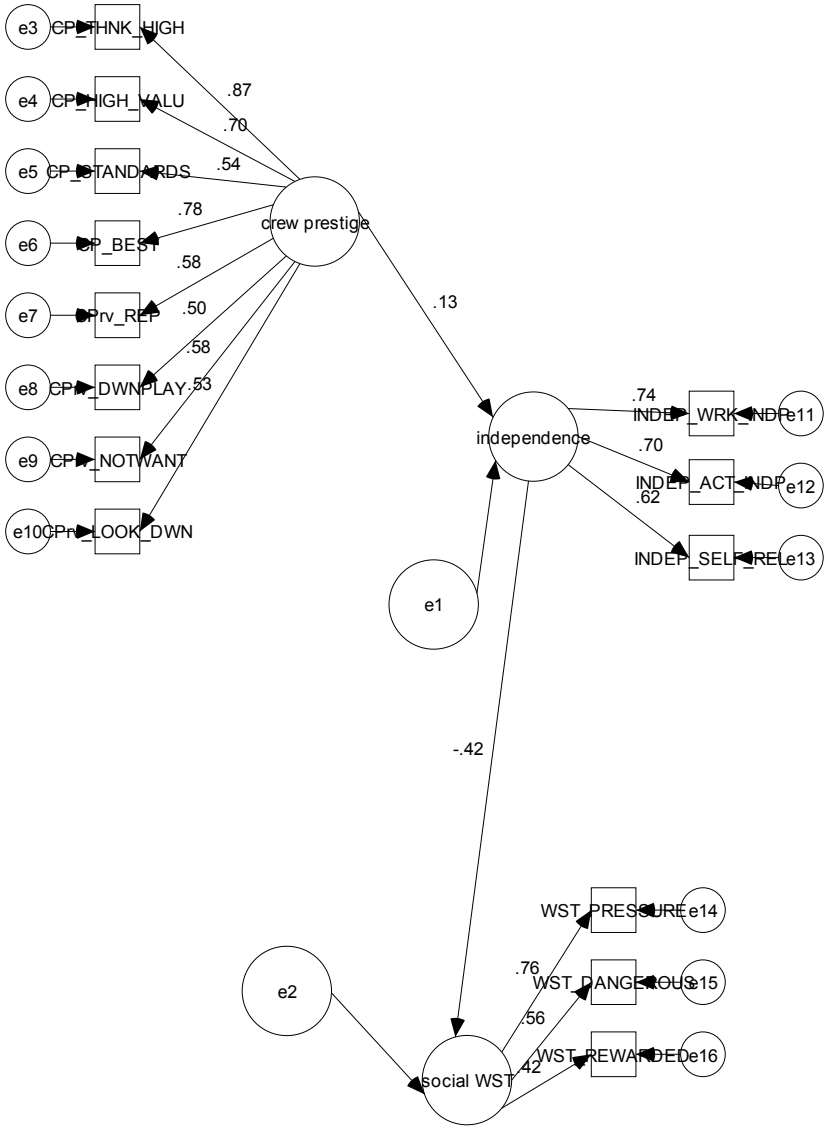

Figure 6. Model of H9c predicting that a crew's level of independence moderates the relationship between crew prestige and work safety tension.

$\chi^2(75) = 179.5$, $p < .001$; *CFI* = .88; *RMSEA* = .08; *SRMR* = .08.

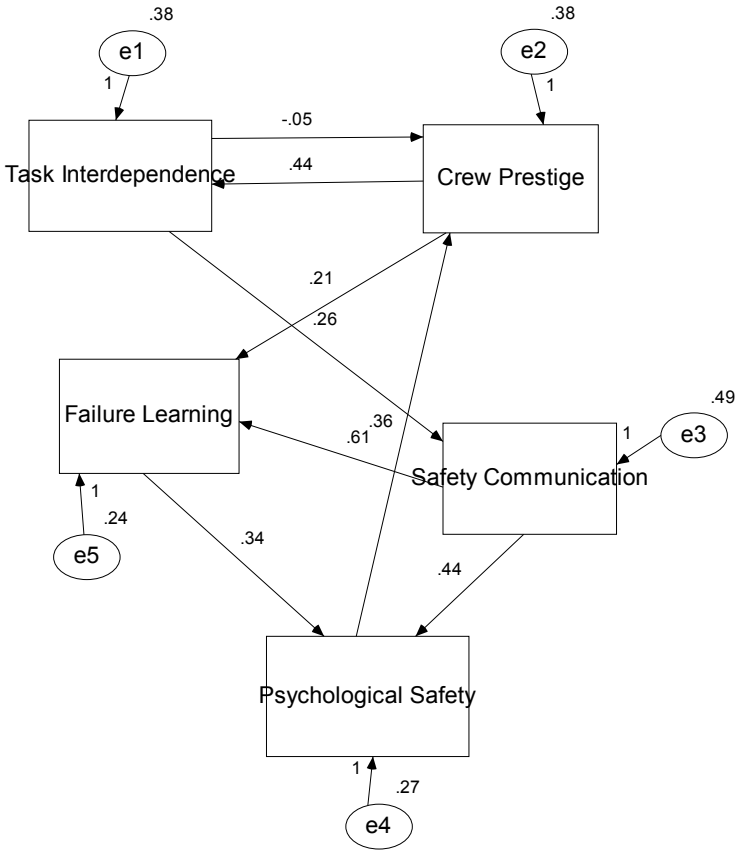

Figure 7. Model 10a depicting relationships among variables measuring the crew interaction environment and communication activities.

$\chi^2(2) = 7.81$, $p = .02$; $CFI = .99$; $RMSEA = .12$; $SRMR = .03$

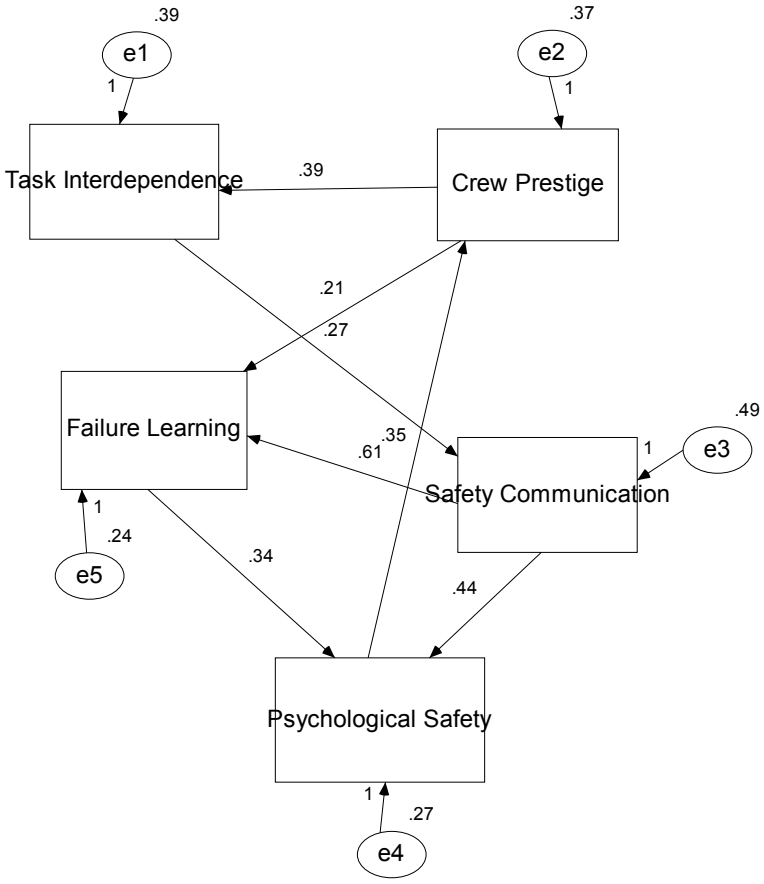

Figure 8. Model 10b depicting relationships among variables measuring the crew interaction environment and communication activities.

$\chi^2(3) = 7.86$, $p = .05$; $CFI = .99$; $RMSEA = .09$; $SRMR = .03$

CHAPTER 6

Integration and Conclusion

The core of this dissertation project is the communicative construction of *safety*. The two studies herein have applied a communication lens to different theoretical and methodological approaches to understanding safety in the high hazard context of wildland firefighting workgroups. I used a mixed methods approach, which enabled me to examine the central concept of safety from two perspectives--high reliability organizing and safety climate—each of which yielded different, but complementary insights. Mixed methods research designs use a combination of qualitative and quantitative methods for the purpose of understanding a phenomenon more completely than one single method would allow (Greene, Caracelli, & Graham, 1989). Mixing methods serves such purposes as enhancing the convergent validity of findings, counteracting biases, and overcoming limitations in one method by supplementing it with another (Greene, et al., 1989). However, researchers should be mindful of whether results from different paradigms are interpretable together. To address this issue, Greene et al. propose three paradigm-based stances related to mixing methods: First, *purists* argue that research paradigms are rooted in ontologies that define the nature of reality; from this view, insights from one paradigm are incommensurable with another (Greene, et al., 1989; Morgan, 2007). Opposite to the purist position, the *pragmatist* approach argues that the practical demands of the research problem should drive which methods are best suited to explore it (Miles & Huberman, 1984). Third, in the middle between purists and pragmatists, a

situationalist position (Kidder & Fine, 1987) suggests that research findings from different paradigms are interpretable together as long as each study maintains the integrity of its respective paradigms.

For this dissertation, I adopted a situationalist position in which I conducted two paradigmatically distinct studies. Study One followed the interpretive paradigm, using qualitative methods to explore critical incident narratives regarding workgroup interactions inductively. Study Two was rooted in a postpositivist paradigm, using quantitative methods to deductively assess wildland firefighter safety culture. To mix the methods and integrate findings, I followed an *initiation* mixed methods design (Rossman & Wilson, 1985) in which areas of incongruence between the two studies were further explored to prompt new insights, recast interpretations of phenomena, and ask different kinds of questions. Following an initiation approach, this chapter integrates Study One and Study Two to examine how the findings inform each other, generating new areas of inquiry, and new ways of conceptualizing safety as a communicative activity.

Study One and Study Two fell within different paradigms that framed the notion of safety in distinctive ways. Each assumed particular sets of conditions that must be in place and defined specific mechanisms that contributed to safety. The studies were couched in opposite research paradigms, which take different approaches to 1) asking questions about the problem, 2) using methods for investigation, and 3) deriving theoretical inferences. This chapter begins with summaries of the findings from Studies One and Two. For each study, I revisited the

central assumptions and conditions underlying its broader theoretical perspective. I then situated the study's findings relative to the assumptions and conditions of its attendant theoretical perspective. Second, I present integrated findings from Studies One and Two. Third, I discuss theoretical and practical implications for this work. Finally, I describe the limitations of both studies and propose future directions for this research.

Study One: High Reliability and Wildland Firefighting

Study One explored safety from the perspective of high reliability organizing. An HRO perspective assumes that organizing occurs under conditions of situational ambiguity, such as fluctuating environments or complex organizational structures (Rochlin, 1993). Based on these ambiguous conditions, threats to safety arise when hazards go unnoticed or errors accumulate. Therefore, this perspective considers that the central *mechanisms* for safety are those that contribute to consistently error-free organizing processes (Weick, 1987). Research examines how member actions and interactions yield consistent patterns for anticipating, noticing, managing and learning about difficult-to-detect hazards (Weick, Sutcliffe, & Obstfeld, 2005; Weick & Roberts, 1993). Theories infer how organizing-in-the-small is recursively related to organizing-in-the-large. That is, theory-building related to HROs identifies how local learning becomes available to the broader organization; and likewise, how the organization's body of knowledge (particularly from accidents) can become relevant and accessible to members in their everyday actions. Study One examined this

recursive interplay between organizational knowledge (e.g., safety rules) and local actions (e.g., routines) at the workgroup level.

Study One used interpretive methods (Charmaz, 2006; Strauss & Corbin, 1998) to examine how two workgroups compared in their routines for performing wildland firefighting work. As previously stated, the HRO perspective assumes that organizing processes occur under conditions of situational ambiguity in which environments are defined by complexity or flux, and hazards are easy to overlook. Under these conditions, it is noteworthy that members of the two crews under study, Manzanita and West Fork, differed in overall experience levels. This difference is important because high and low experience affected the mechanisms for reliability differently. Specifically, the findings for the four research questions showed that patterns for anticipating, noticing, managing and learning about difficult-to-detect hazards unfolded differently for the less-experienced crew (Manzanita) as compared to the more-experienced crew (West Fork).

The first research question examined workgroup level routines for implementing safety and firefighting tasks. This question explored the ways the two crews' members engaged in organizing, or *co-oriented,* through communicative interactions for implementing safety and firefighting tasks. From an HRO perspective, the primary mechanisms for safety are the consistent patterns of action for managing and anticipating hazards. These consistent patterns of action were the crews' local routines. Findings revealed that the crews differed substantially on three routines: *planning*, *use of safety rules* and *authority*. The two crews were each aware of their

collective experience levels, and as a result, how they needed to interact within the crew in order to facilitate consistent actions and stay abreast of emerging hazards. For example, the high number of inexperienced Manzanita members created a practical need for members to learn as quickly as possible. Therefore, a mentorship interaction pattern was embedded in the crew's planning, rule-use and authority routines. West Fork members, on the other hand, were highly experienced and often tasked with handling challenging situations that other crews were not qualified to handle. The mechanism for reliable actions took a different form for West Fork than it did for Manzanita. Whereas the goal for most of Manzanita's activities involved helping inexperienced firefighters gain experience, the main goal for West Fork members was to gain experience acting autonomously because they considered themselves to be experts. Thus, mechanisms for reliably safe action were rooted in developing skills at individually evaluating situations, devising and defending plans, and voicing dissent. Interactions involving autonomy, discernment and asserting one's position characterized the planning, rule-use and authority routines.

Because the situational ambiguity of the complex and ever-changing physical environment plays such a prominent role in HROs, the second research question examined how the two crews managed material space when implementing firefighting tasks and safety. For Manzanita, configuring the fire's spatial environment involved talking through options for locating escape routes and safety zones in relation to various terrain features and the fire. This process of managing space was embedded in the mentorship-based interactions between members that

comprised the planning and rule-use routines. In contrast, several West Fork members described close-call incidents in which their safety zone was inadequate and they had to run from the fire. These experiences created a visceral understanding of space that caused them to change their subsequent implementations of safety zones. Thus, through close-call incidents, members deepened their understandings about difficult-to-detect hazards that trigger sudden changes in fire size, and adapted new methods for configuring their firefighting work environments. They gained understanding about where to place safety zones and escape routes and began to anticipate how the time of day and weather changes would influence certain spatial configurations (e.g., the proximity of safety zones relative to the fire) and ways of responding to them as conditions changed.

The third research question explored how past conversations (coorientations) that referenced the workgroup and safety routines served as a basis for members' ongoing instantiations of the organization. *Texts* refer to accumulations of past coorientations, or interactions (Taylor & Van Every, 2000). Relative to high reliability organizing, this research question addressed how past interactions set a precedent for future interactions. Manzanita's interactions reflected that members prioritized the importance of training for its relatively inexperienced members. As such, their way of addressing this need was to embed a mentorship-based interaction in their routines. West Fork's needs involved pushing members to act expertly and independently; to address the need, members (somewhat unintentionally) challenged themselves to engage in conflict-based interactions in which they practiced asserting

themselves. From these different sets of needs, the two crews differed on three *texts,* including notions of *groupness*, *efficiency* and *safety*. For Manzanita, groupness was achieved through task-related communicative activities that built trust and cohesion. Efficiency was defined by members' abilities to notice and communicate about problems and safety concerns quickly and accurately. Safety was rooted in learning practices that pushed less experienced members to see and talk about fireline situations. All three of these texts interrelated to contribute to an environment that facilitated free exchange of questions and encouraged members to raise concerns and insights to facilitate learning. For West Fork, groupness was achieved through non-task related "fun" activities in which members played sports together or "joked around." However, the defining aspect of the West Fork's groupness was related to its expectations for professionalism; thus, it was equally important for members to demonstrating that they knew the difference between "work time" and "play time." Efficiency meant moving quickly and acting without supervision. Safety resulted from members' abilities to think and act appropriately as individuals. These three texts contributed to creating expectations for members not only to act as experts, but also to see themselves as such.

The final research question synthesized how the findings about coorientation, management of material space and crew texts affected high reliability organizing. Findings from Study One suggested that both Manzanita and West Fork crews operated as models of high reliability organizations, but that they did so by creating different types of expectations and interaction patterns. Further, both environments

were better suited for some firefighters more than others. Specifically, less experienced firefighters would benefit from Manzanita's encouragement of open dialogue and learning as mechanisms for generating consistently safe actions. In contrast, firefighters with a baseline of experience should seek employment on crews like West Fork where they would be pushed to use their expertise and gain deeper experience through facing tough challenges.

Study Two: Safety Climate and Wildland Firefighting

Like the HRO perspective, the safety climate perspective also takes safety as its central problem. This perspective assumes that organizing processes occur under conditions in which high rates of production or output are prioritized (Zohar, 1980; Zohar & Luria, 2005). In this context, the primary obstacles to safety are attitudes and patterns of communication that de-value safety or discourage the implementation of it (Morrow, et al., 2010). Therefore, this perspective considers that the central *mechanisms* for safety are attitudes and behaviors that demonstrate value and commitment to safety by both vertical and lateral organization members. Safety climates depend on supervisors and subordinates sharing the same value and interactions for safe actions, while co-workers must also demonstrate their mutual commitment to prioritizing safe behaviors (Hofmann & Mark, 2006). Research on safety climates take a post-positivist view, typically using quantitative methods to identify dimensions of the construct and to model relationships among predictor and criterion variables in various production-based organizational contexts, such as manufacturing and construction (Guldenmund, 2000; Zohar, 1980; Zohar & Luria,

2005). Safety can be problematic in industrial contexts because workers struggle against time pressures to meet demanding production goals. Implementing safety involves extra steps and takes extra time, which hinders workers' abilities to meet production goals. As such, the social environment—hierarchically or laterally—might be hostile to members who display safe behaviors (and thus are slow). Therefore, safety climate studies are particularly concerned with factors in the work environment that discourage safe action.

The study of safety climates also applies to high hazard organizations such as wildland firefighting in which the pressures to respond quickly to changing circumstances or emergent hazards might encourage members to cut corners in implementing safety. In wildland firefighting, as with other HROs, safety not only depends on safe *attitudes*, but on members *communicating* their safety concerns. On this basis, Study Two assesses the safety climate of wildland firefighters across three federal agencies. The design of Study Two's safety climate survey incorporated key findings from Study One that informed the wildland firefighting communicative interaction context. The findings included 1) how crew staffing patterns (co-located, dispersed) were related to work style (independent, task interdependent), crew communication activities and the crew's interaction environment; 2) how independence and task interdependence related to each another in the context of wildland firefighting work; and 3) how crew communication activities shaped (and were shaped by) aspects of the crew interaction environment.

The first research question examined staffing patterns influenced safety climate. The difference between co-located and dispersed staffing patterns was important in Study One because it seemed to shape each crews' ability to institute regular communication-based routines, and secondly, groups who work together all the time might be more comfortable together than groups whose members are always coming and going. The Study Two findings revealed that co-located crews and dispersed crews differed (as would be expected) with co-located crews revealing significantly higher task interdependency and significantly lower independence than dispersed crews. However, it was notable that co-located and dispersed crews did not differ significantly on any of the interaction environment or communication activity variables. This finding suggested that staffing patterns might play a less important role in the safety climate than indicated in Study One. The implication for high reliability organizing is that consistency in action can emerge even if there is inconsistency in staffing. Considered in relation to Study One, this finding points to the importance of crew *text*. Manzanita and West Fork enacted their crew texts for efficiency, groupness and safety in different ways, and likewise, the texts informed their actions. Their collectively-held understanding of what made their crews distinctive served as a guide for their actions. Thus, even though West Fork members did not work together often, they still collectively understood that their crew text for efficiency, for example, meant that they were to accomplish tasks quickly without supervision. The crew text provided guidelines for action that were consistent, regardless of whether the crew worked in a co-located manner or not.

The second research question investigated how independence and task interdependence related to each other in influencing safety climate. This finding indicated that task interdependence and independence are not, in fact, opposite measures. Instead, these concepts appeared to capture different types of activities in the wildland firefighting context. Task interdependence was a significant and strong predictor (along with failure learning) of crew prestige. From this finding it can be inferred that the degree to which members felt it was necessary to work together on tasks might have boosted their feelings that their collaborations were necessary to produce high-quality work. Thus, crew prestige might have been strongly tied to high esteem of the group as a whole, which might have cued them to value the ways they coordinate closely with one another. A strong sense of task interdependence might cue an awareness of the collective crew, which may cause firefighters to consider more conservative actions regarding hazards because the safety of the entire group is at stake. Therefore, high esteem for the crew might have been related to concern for the collective, which would in turn promote conservative actions. The crew's deliberate efforts to monitor the safety of the group could contribute to thinking that the crew is competent at keeping members safe by way of smart decisions. Thus, high esteem for a competent, safe crew might indicate crew prestige.

On the other hand, task interdependency appeared to also assess basic aspects of firefighting work—interdependency was a comfortable constant for members. Firefighting tasks tend to be large scale, requiring coordination among numerous resources. Therefore, a measure of task interdependence in this context may only

describe the nature of the work, rather than indicating anything distinctive about how particular crews operated. This highlights an important point in assessing performance and other measures in high reliability organizations. Specifically, researchers should be aware that some measures might not address aspects of the crew, but instead address aspects of the work. Thus, if crew-level comparisons are the focus, some measures might not yield conclusive or specific results. This could have been the case with measuring task interdependence in wildland firefighting. Measures of satisfaction or cohesion could begin to differentiate between task interdependence and independence. For example, reports of high task interdependence combined with high cohesion might indicate that task interdependence is a characteristic for how the workgroup organizes, whereas reports of high task interdependence and low cohesion might point to the interconnectedness of work tasks in general. An additional point is that the published scales for this study all involved communication activities in some way, but communication was subsumed under the measure of another concept, such as communicating about safety issues (safety communication), or communicating in order to coordinate on tasks (task interdependence). To fully capture the degree to which crews value communication activities in general, it would be useful to design a scale that specifically measures communicative activity as being a defining aspect of the workgroup, something members value and take pride in, and the degree to which their workgroup identity is rooted in their communication activities (or lack of).

In contrast to task interdependence, opportunities to work independently seemed to be more novel. Findings from several hypotheses indicated that crews in

which their members were accustomed to making their own decisions might have trusted their own judgments more and, as a result, might have been more resistant to the influences of the group regarding taking risks. This resistance to the group's pressure to take risks would likely be enacted through members communicating dissent or concern. Thus independence might be linked with an ability to enact authority through communicative action, as the findings from West Fork's authority routine indicated.

The third research question explored how several safety climate variables interrelated. The findings drew a clear distinction between minimal conditions for members to act safely, and deliberate activities designed to enhance learning and comfort of the collective crew environment. First, safety communication appeared to capture the basic and necessary conditions for safety on the crew such that safety communication partially diffused pressure to engage in hazardous activities. To contrast, failure learning seemed to be a deliberate activity rather than a spontaneous one. These findings point to safety communication as being a more important predictor for safety climate, in general, because members will feel safer when they are able to speak freely about questions and concerns.

Second, psychological safety measured the degree to which the workgroup environment felt safe for interpersonal risk-taking. Having strong safety communication and failure learning activities in place appeared to facilitate an environment in which there were fewer social costs associated with expressing concerns and participating in learning, particularly learning from mistakes. This type

of crew environment seemed important in wildland firefighting because firefighters face ambiguous fireline circumstances in which it often is difficult to discern and prioritize hazards; as a result, firefighters need to feel comfortable communicating with each other.

Integrating Findings: A Triangulation Approach

The primary reason for conducting a mixed methods study using an *initiation* approach is to use insights derived from one research paradigm to inform findings from another while maintaining the integrity of both paradigms (Greene, et al., 1989; Leech & Onwuegbuzie, 2009). Greene et al., argue that researchers who use this approach often are looking for areas in which the findings from one study diverge from the findings from another. These areas of disagreement can point to new research questions. This section integrates findings from Studies One and Two to illustrate how one perspective informs the other. Therefore, in the following discussion, I apply the central question from the HRO literature to the safety climate literature. The central HRO question is: How do patterns of actions and interactions contribute to members' efforts to anticipate, notice, manage and learn about difficult-to-detect hazards? I also apply the central question from the safety climate literature to the HRO literature, specifically: What are the social pressures that encourage or discourage safe action? I have organized this section around key concepts: communication and safety, groupness, task interdependence versus independence, and prestige.

Communication and Safety

Two key concepts around safety emerged from Study One, which informed Study Two: safety communication and failure learning. Study One showed that Manzanita made safety visible through regular debriefings during which there was ongoing interaction between members. In these interactions, members defined the situations and discussed which action options were available. Manzanita also regularly conducted retrospective learning-based discussions, which members said were important for creating a comfortable communication atmosphere on their crew. In contrast, West Fork's safety text was around voicing their views, acting as individuals and developing discernment that was both tactical and social, enabling them to notice problematic situations and to overcome social constraints in order to take action. West Fork did not routinely engage in a retrospective learning-based discussion.

Sources for safety-related pressure were different for the two crews: Manzanita members engaged in dialogue between mentors and mentees as a way to understand situations and decide which actions to take. Thus, there was pressure to engage in learning through communication—to discuss situations and ask questions before engaging in firefighting action. West Fork members described a pressure to act as experts, which was opposite from Manzanita. There was pressure to act independently and decisively, and to take on more challenging situations than less-experienced crews. However, a large part of West Fork's expertise was communicatively developed (and demonstrated) as they resisted enacting bad

decisions that other firefighters—from their crew or from other crews—recommended. They described their communication-based methods for voicing dissent and asserting themselves in order to fulfill their expert role.

Study Two indicated that safety communication—in-the-moment communication—was a foundational, necessary condition for a safety climate. Safety communication was the strongest predictor of low social work-safety tension. Thus, being able to communicate about hazards helped people to feel that they had control over how they would handle inherent job risks. This hints at the high reliability notion of *redundancy,* which is the idea that organizational systems containing duplication and back-up plans therefore contain more possible ways to successfully and safely complete a task (Weick, Sutcliffe, & Obstfeld, 1999). Redundancy also takes the form of skepticism. Thus safety climates in which members feel free to voice concerns in-the-moment (have high safety communication) will be more redundant, and thus, more highly reliable. Manzanita members incorporate safety communication into their dialogue-based coorientations with one another while West Fork members engaged in conflict-based coorientations in which they asserted a position. Both the conflict- and dialogue-based models for redundancy reflect the notion of skepticism. Through dialogue, Manzanita members ask questions of each other in order to discover whether they have fully considered the situation and action options. Dialogue coorientations place the mentor in the position of explaining and justifying their rationale to mentees. The dialogue process might involve mentor and mentee confirming the soundness of safety of a plan, which would be a form of

duplication. Alternatively, mentees might ask questions about hazards that the mentor overlooked, thus introducing a form of skepticism into the interaction that can be further discussed. Similarly, West Fork's conflict-based coorientations introduce skepticism, because they force the coorienting parties to justify the safety of their positions.

Failure learning routines were a defining element of the Manzanita crew, whose members highly valued the failure learning activity. West Fork members did not engage in such a practice, largely because their dispersed staffing patterns did not enable them to easily institute it. However, West Fork did not appear to be hindered by their lack of retrospective learning routine, while Manzanita did seem to greatly benefit from them. Study Two results indicated that failure-based learning was an equally strong predictor as safety communication in contributing to a crew's psychological safety. This finding indicates that the psychological safety of a crew's interaction environment benefits from open communication, in general. However, the deliberate nature of conducting retrospective (e.g., failure-based) learning discussions might hint at a particular type of crew environment. For example, in Study One, both Manzanita and West Fork appeared to be able to communicate freely with each other, however Manzanita's deliberate efforts to engage in learning-based discussions reflected a collectively-held view that the purpose of their crew was to help members learn. In summary, safety communication and failure learning were central predictors influencing the psychological safety of the workgroup's climate.

Groupness

Study One illustrated that Manzanita's sense of groupness involved concern for the collective of the group while West Fork embraced a broader sense of collective identity as experts. Further, the notion of workgroup *texts* illustrated how notions of groupness informed their actions. Manzanita's concern for collective learning prompted them to engage in activities that promoted crew cohesion and conversation. West Fork's expert identity prompted members to take on challenging assignments and act autonomously without supervision.

From a safety climate perspective, the groupness *texts* for both Manzanita and West Fork add insights to understanding how social pressures arise from a safety climate. Texts are past conversations that have set a precedent for how future interactions should unfold. Therefore, Manzanita's groupness text, based on building cohesion, sets expectations for members to value cohesion and do what they can to promote it within the crew. Conversely, members who act in ways that divide the crew or who refuse to participate in collective activities will face social costs. West Fork's groupness text, based on being independent experts, set expectations for members to be autonomous and resourceful on their own. This expectation might have pressured members to feel as though they should avoid asking questions for fear that they would appear to be less than an expert, or not worthy for their position on the crew. Therefore, different crew texts point to the types of behaviors crews expect of members, and simultaneously, the types of behaviors that marginalize or belittle. Behaviors that are and are not accepted can inform the types of social pressures

influencing safety-based activities in the workgroup. Thus, safety climate literature highlights the importance of supervisors and co-workers in creating environments in which members feel comfortable engaging in safety-based activities. Considering additional social factors (e.g., identities, expectations) in safety climate literature can add breadth to the work.

In Study Two the measurements for groupness were grounded in communication activities and task interdependence. It makes sense to measure a sense of groupness by focusing on activities that bring members together; however, Study One showed that a sense of groupness was also rooted in individualism. West Fork exhibited a strong sense of groupness, but it was based on their collective identity as *independent* experts. Further, their sense of collective identity was invoked during activities that brought members together, but that they likely took for granted, such as joking around or engaging in a sport-based activity. At an organization-wide scale, it might be difficult to capture the variety of activities that cue groupness for other crews like West Fork who assemble around their individualist identity rather than their mutual engagement in typical group-based forms of organizing. However, open-ended survey responses, observation of crew activities, and additional interviews could be used to gain a wider understanding of various forms of groupness.

Independence versus Interdependence

In Study One, independence and task interdependence emerged as the defining features of the two crews: West Fork was a highly independent crew, based

largely on their dispersed staffing patterns; Manzanita was a highly task interdependent crew, based on their co-located staffing and regular occurrence of learning-based communication routines (e.g., AARs, retrospective discussions, proactive planning dialogues).

The intention for testing task interdependence and independence in Study Two was to identify crews that were similar to either West Fork or Manzanita. However, crews often scored highly on both measures, which pointed to richer conclusions. Thus, instead of using the measures to identify which crews were task interdependent versus independent, Study Two ultimately explored how independence and task interdependence each influenced safety climate. The concepts, task interdependence and independence, appeared to capture different types of activities in the wildland firefighting context.

On one hand, task interdependence was a significant and strong predictor (along with failure learning) of crew prestige. This finding suggested that the degree to which members felt it was necessary to work together on tasks might have boosted the feelings that their collaborations were necessary to produce high-quality work. A strong sense of task interdependence might cue an awareness of the collective crew, which could cause firefighters to consider more conservative actions regarding hazards.

On the other hand, task interdependency appeared to assess basic and ongoing aspects of firefighting, as the work tends to be large-scale, and it typically requires coordination among numerous resources. Thus, task interdependence may simply cue

members to think about the nature of the work rather than distinctive aspects of how their crews operated (which was the intended measure). In contrast, firefighters did notably vary in their opportunities to work independently. Independent crews were found to be more resistant to pressures to take risks than were less independent crews. Thus opportunities to exercise independent action enable members to feel more control over their circumstances, and as a result, less pressure to go along with hazardous decisions made by groups.

Prestige

Study One indicated that West Fork members thought highly of their crew and strived to uphold its highly professional reputation within the firefighting community. Thus, West Fork was a prestigious crew. Manzanita members did not talk directly about their crew being prestigious, but that did not mean that they lacked prestige. Rather, for them, they took pride in playing a pivotal role in facilitating less-experienced firefighters' efforts to gain experience. While highly valued, they did not talk about their prestige in terms of upholding a particular "reputation." In Study One, West Fork members, whose interviews invoked the concept of crew prestige directly, defined the strongest indicators of it. West Fork members talked about how their crew had a good reputation, and that working there "looked good" on their firefighting resume, etc. Thus, for conducting Study Two, I anticipated that the notion of crew prestige would be linked to upholding a capable reputation and therefore, pressures to perform when safety was not fully implemented--a feeling that some West Fork members said they experienced.

However, Study Two revealed very different results than expected. First, results showed that crew prestige was a significant predictor of psychological safety when combined with failure learning and safety communication. The higher the collective esteem about the crew, the more members valued their contributions and wanted to share them, thus the higher their psychological safety. In contrast to Study One, this finding linked crew prestige with a desire to contribute to the collective group, rather than linking prestige to independent actions.

Second, I hypothesized that high crew prestige would predict high pressure to engage hazards (social work-safety tension). This hypothesis was significant, but in the opposite direction than expected. High crew prestige, in fact, predicted lower levels of social work-safety tension ($\beta = -.28$, $p < .01$). If prestige indicates that certain actions rewarded with a good reputation, then this finding indicates that fire crews value conservative actions toward engaging hazards, rather than taking bold risks.

In a third hypothesized relationship, crew prestige was found to be the strongest predictor of safety communication (along with task interdependence and independence). Items in crew prestige measured the degree to which a crew was highly regarded both by members and within the firefighting community. This finding could be interpreted to mean that freedom to voice safety concerns upwardly and in general (i.e., safety communication) among the crew was a highly regarded activity in wildland firefighting. Further, for members to consider their group to be prestigious, they must think highly of the collective, including the ways the crew

accomplished work, the degree to which it upheld high standards, and the belief that membership on the crew was sought-after within firefighting.

Therefore, Study Two diverged from Study One findings on the notion of prestige. In Study One, prestige was linked to West Fork's autonomy, high expertise and pressure to take on hazards that other crews were not experienced enough to handle. In contrast, Study Two revealed that prestige, within the broader wildland firefighting profession, was linked to safety communication behaviors, a lack of pressure to engage hazards, and the psychological safety of the crew's interaction environment. This diversion in results might indicate that West Fork's emphasis of living up to a certain reputation did not, in fact, reflect the notion of prestige as it is conceptualized within the broader firefighting community. Perhaps West Fork's emphasis on their good reputation was a to justify how their particular style of crew organizing was valuable, and set them apart from other crews.

Theoretical and Practical Implications

The two studies have illustrated that communication processes critically shape how safety is accomplished in wildland firefighting workgroups. Both studies demonstrated that wildland firefighting is not an individual activity, but a group one. Therefore, safety is a collective accomplishment that is socially defined through the workgroup's appropriate and normative safety actions. Study One showed the importance of communication in shaping everyday enactments of tasks and safety; findings illustrated how members' patterns of interactions set a precedent for appropriate behavior. These expectations influence how members enact tasks. Study

Two illustrated that communication-based activities helped members to feel less pressure to take risks and enhanced their perception that the workgroup was a safe interpersonal environment. Based on the findings from both studies, this section proposes several theoretical and practical implications of this research.

Theoretical Implications

Both studies in this dissertation demonstrated the utility of using a communication-based approach to understand safety. Theoretical contributions of this work can be applied to high reliability organizations and safety climate in order to better understand how safety is *grounded in action,* is a product of *preoccupation with failure* and *redundancy*. This dissertation also demonstrates the importance of examining phenomena at the interaction- and workgroup-levels of analysis. This section describes theoretical implications; practical implications follow.

Grounded in action. A CCO approach to high reliability is grounded in action, assuming that action is social and practical. Therefore, a communicative perspective asks *in what ways do members enact appropriate actions?* Here, *appropriate action* is not purely based on what is going on in the environment, but strongly subject to the social pressures at the workgroup level that shape what is accepted as normative and appropriate action. Study One described the notion of crew *text* as a record of past conversations in which members had instantiated the organization, and which had set a precedent for current and future actions (Taylor & Van Every, 2000). When applied to safety climate literature, the notion of crew *texts* could help elucidate the types of behavior expectations that emerge in workgroups

and why. For example, Manzanita's safety text involved engaging in communication activities that built trust and cohesion among members. Members expected themselves and others to participate communicatively. The resulting safety climate was comfortable and conducive for dialogue.

Wildland firefighting workgroups were a fruitful context for qualitative, CCO-based research due to the prevalence and importance of the organization's safety rules in members' ongoing interactions. It is theoretically and practically interesting that the interviewees interpreted the safety rules so differently, especially since the participants indicated that the organization largely considers the safety rules (the Ten Standard Firefighting Orders) to be self-evident and easy to apply to fire situations. It is further notable that the two workgroups' uses of routines shaped members' interpretations of how to implement tasks and safety. Routines functioned as the translation of the safety rules into physical action; the types of routines that emerged reflected the workgroup's texts (Taylor & Van Every, 2000). Thus, wildland firefighting was a rich environment for studying CCO because firefighting efforts on large fires often function in a dispersed and emergent way. Emergent contexts require members to enact the organization by drawing from their previous instantiations of it, in addition to drawing from various organizational elements. These emergent processes were common among the wildland firefighting interactions (co-orientations) examined in Study One.

Preoccupation with failure. Communicative interactions and safety climate deepen our understanding of high reliability organizing as an emergent process that

occurs at the workgroup level of analysis. Specifically, scholars consider that one defining element of HROs is that they are "preoccupied with failure," meaning that accidents provide crucial opportunities to unearth previously unseen hazards. Findings from accident investigations are considered to be forms of "organizational knowledge." For wildland firefighters and other HROs, organizational knowledge is then dispersed to members via new rules or safety policies (Zeigler, 2007). However, the effectiveness of rules and policies to protect worker safety—and to truly function as useable knowledge—depends on how rules and policies are translated into action. Study One showed that this translation is an emergent, interactive process at the workgroup level. Therefore, researchers could extend HRO literature by researching how workgroups are "preoccupied with failure" through various interactions. Study One examined critical incident narratives; researchers could extend the work by examining everyday communication episodes. Research questions to consider include: How do workgroups incorporate the findings from large-scale accident investigations into their daily talk, and into their ongoing safety and task-based activities? How do workgroups incorporate their daily small-scale mistakes into routine safety-based conversations? Also, what workgroup-level social factors influence whether members value and participate in communicative learning-based routines? What specific workgroup-level values predict whether a workgroup maintains and perceives benefit from failure-based learning routines?

Redundancy. One mechanism for reliability in the HRO literature is the notion of redundancy. Redundancy refers to duplication and backups, but also

skepticism—the ability for members to question one another (Weick, Sutcliffe, & Obstfeld, 1999). In Study One, both Manzanita and West Fork had redundancy built into their coorientation interactions. For Manzanita, redundancy was built into the mentorship dialogue that encouraged inexperienced members to ask question, often ones that supervisors did not expect. As a Manzanita supervisor noted, "We get great questions from the newer [less experienced] folks—about things I take for granted, things I don't even think about anymore, but they bring it up." Manzanita's model for redundancy is duplication as members evaluate a situation, talk about what they are seeing, and decide how to take action. West Fork follows a skepticism model for redundancy in which members gain experience asserting themselves, using the organization's rules as a trump card to push a plan or voice dissent. The above two models for redundancy point to a potential area for theoretical expansion. The present models—duplication and skepticism—were rooted in the coorientation interactions of members. However, the ways members interacted (e.g., dialogue or conflict) extended from the characteristic interaction patterns of Manzanita and West Fork. Across the organization as a whole, there are likely numerous types of interaction patterns that inform how workgroup members act. Thus, there might be numerous ways that members create redundancy as they negotiate their activities through communicative interaction.

Member learning. Study One also showed that the two crews had different learning models that served different purposes. In contrast to Manzanita's dialogue-based model, West Fork members used a conflict-based learning model. These

models functioned in alignment with each crew's text such that Manzanita members' dialogue-based learning model functioned to foster trust and cohesion among members, while West Fork's conflict model helped members to think independently. Study Two partially corroborated these findings revealing that high levels of safety communication and failure learning significantly and moderately predicted higher levels of psychological safety. In this case, psychological safety acts as a rough equivalent for trust and cohesion as it measures the degree to which a crew is safe for interpersonal risk taking. Also, higher degrees of independence were related to lower levels of social work-safety tension. Thus, thinking for one's self may help a firefighter to develop discernment in evaluating hazards and, importantly, to trust that he or she will not get swept up into hazardous dysfunctional momentum of the workgroup.

In HROs, high performance is emphasized. The two studies showed distinct communication-based models for member learning. Manzanita's mentorship dialogue model was easy to identify. However, while less immediately apparent, West Fork's conflict-based interactions also comprised a learning model. These conflict interactions that members described were formative experiences helping them to develop communication strategies that resulted in action (e.g., dissenting effectively, asserting a plan, etc.). These findings illustrated that HROs should prioritize and encourage member learning in its numerous forms, because different models for learning are interactive. Therefore, practice engaging in different kinds of communicative interactions builds members' communication repertoires. A deep

repertoire equips members to apply different communication strategies to a variety of circumstances, and with various effects.

The danger of ideal types. Safety climate research and HRO studies tend to implicitly assume that more communication, and a greater sense of group cohesiveness are "preferred" ways of organizing safely. Indeed, both Studies One and Two revealed that these ways of organizing promoted a sense of togetherness, enhancing overall psychological safety and helping members feel comfortable voicing concerns and insights. Manzanita offered what could be considered an ideal type of crew that was highly effective at building members' experiences and engaging them in planning routines. Their highly communicative interactions illustrate the classic model for collective sensemaking in high reliability organizing (Weick, Sutcliffe, & Obstfeld, 2005). However, there is a danger to exalt Manzanita as the single ideal model for workgroup organizing based solely on the crew's highly communicative, cohesion-building activities because these activities do not represent the range of social situations one might encounter in an HRO. Manzanita might not offer a challenging enough social environment for members seeking to build a repertoire of communication skills helpful to them in higher levels of the wildland fire command authority.

In HROs, time pressure requires that members must act decisively. In doing so, their communicative interactions need to produce action (Taylor & Van Every, 2000). Turning communication into action requires that members generate authority. Study One illustrated the importance of crews like West Fork, in which expectations

to act autonomously provided members with opportunities to practice assuming authority, asserting plans and voicing dissent. While these accounts of West Fork interactions were characterized by conflict, it was the very engagement in conflict-based interactions that enabled members to practice advocating for themselves. In doing so, they were able to see how their actions generated results, oftentimes interrupting a potentially problematic trajectory of action (see also Barton & Sutcliffe, 2009). Because HROs require tight coordination under time pressure and intense circumstances, conditions do not always foster dialogue-based interactions. Members need to know how to engage other firefighters in ways that result in immediate effect. Thus, exercising authority through communication depended on members effectively drawing the organization's rules into the conversation. Invoking the organizations rules enabled their communication to *do* something (Cooren & Taylor, 1997), such as refusing or asserting a plan.

In summary so far, neither Manzanita nor West Fork exemplified *the* ideal model for workgroup organizing. Instead, each crew provided a valuable environment for members at different stages of experience to hone skills related to communicative interaction, evaluating circumstances and devising plans. In HROs, different ways of communicating contribute to different kinds of results. Mentorship requires one kind of communicative interaction, while exercising authority requires another. However both interactions are necessary for safety. HRO research should examine the various types of communication interactions, how these interactions are perpetuated in workgroups, and how they contribute to aspects of high reliability

organizing and safety climate. The next sections connect this project more broadly to communication-based lines of research regarding 1) the wildland firefighting context and 2) safety and health.

Wildland firefighting context. In recent decades, the wildland firefighting context has captured the interest of researchers from a variety of disciplines, particularly organizational communication. This engaged scholarship has resulted in fruitful collaborations between scholars and the wildland firefighting community (Simpson & Seibold, 2008). Studies examine identification and organizational control (Bullis & Tompkins, 1989), organizational discourses in wildland firefighting (Thackaberry, 2004; Zeigler, 2007), member error detection (Barton & Sutcliffe, 2009), and childhood socialization that prepares "country boys" for wildland firefighting work (Desmond, 2006, 2007, 2010). In a similar context, Scott and Trethewey (2008) examined the municipal firefighting environment and found that municipal firefighters chose ways to make sense of hazards that were consistent with their preferred sense of identity. These finding are similar to Study One findings in which Manzanita members approached situations and tasks in ways that were consistent to their image as a training-based crew, while West Fork members approached firefighting tasks in ways that were consistent with the perception that they were experts.

Safety and health. This project also connects to emerging organizational communication research on safety and health, in particular 1) ways that organizational discourses define notions of risk and safety (Zoller, 2011), and 2) how

the communication environment contributes to member efficacy in voicing questions and influences safety outcomes (Real, 2008). Even though the contexts of the previously listed studies are not wildland firefighting, this dissertation contributes to the body of knowledge related to how organizational routines, and the communication environment contribute to safety.

Practical Implications

Practical implications for Studies One and Two point to four key insights. First, different crews fulfilled different training needs. As previously mentioned, safety in HROs depends on numerous types of communicative interactions that serve different purposes—from fostering mentorship to gaining practice with asserting authority. Manzanita and West Fork were exemplars of these two distinctive learning models. Given the amount of complexity, and the fluctuating environments found in HROs like wildland firefighting, it makes sense to ease members into the profession in ways that allow them to progressively build different communicative skill sets. Thus, the organization could designate several levels of training and the types of communicative skills that could be emphasized and practiced at those levels. Then, crews could be designated to provide training that fulfills those communicative goals. For example, crews like Manzanita that use a mentorship communication model of interaction, could provide guided exposure to hazards for less-experienced firefighters. As members progress in their careers, they could transition through the various levels of crews (and communication skill sets). Through the process, members learn various communication skills. For example, through opportunities

working with crews like West Fork, members would practice engaging in interactions in which members assert authority and act autonomously. This development of skills enables members to safely navigate numerous types of social encounters in HROs and to overcome pressure to take unnecessary risks, an aspect of safety climate.

Second, consistency in routines held members accountable to safety behaviors. Study One showed that Manzanita's regular routine of engaging in retrospective learning-based discussions set the expectation that all members should have something to contribute to the conversation. As a result, members actively monitored their environments and firefighting actions throughout the day in order to have something to talk about. The regularity of Manzanita's retrospective learning routine was the primary reason for its success. Because it occurred informally every day, and more formally after every fire assignment, members knew to expect it—and, expecting it—actively observed their environments for questions to ask and discuss. This result pointed to the importance of the regularity of the routine, but also the crew supervisors' alliance in their commitment to the routine. Everybody valued the routine and felt that it was consistent with furthering the mentorship goals on the crew. It would not be effective for an organization to impose a new safety routine onto its workgroups. Instead, to be effective, all members must value the activity as reflecting the overall goals of the crew. The HRO can provide guidance to crews by proposing different kinds of routines, just as the wildland firefighting organization provided the after action review (AAR) model. Manzanita adopted the model as furthering their crew goals, while West Fork members felt that daily AARs were not

useful for their crew. Therefore, the HRO should gather workgroup leaders together from throughout the organization in order to discover the variety of goals that workgroups define for themselves. Once the range of workgroup goals or defining purposes are specified, the organization and workgroup leaders can develop communication-based routines that further the various types of workgroup goals and contribute to safety.

Third, communication activities in general fostered comfortable interaction environments. Study One results indicated that Manzanita's communication activities greatly contributed to members' comfort with interacting on the crew. Based on West Fork's accounts of conflict, it at first seemed that the crew did not have a comfortable interaction environment. However, after further reflection on the data, members did seem comfortable interacting with their crewmembers; however, their interactions challenged them to step out of their comfort zones in order to assert themselves. According to participants, these types of interactions were valuable in developing their authority as firefighters. Study Two further indicated that the freedom with which members are able to communicate with co-workers and supervisors about safety concerns (e.g., safety communication) was the strongest predictor of psychological safety and the primary predictor for low social work-safety tension. Safety communication refers to in-the-moment communication and it was distinct from retrospective learning activities (e.g., failure learning, AARs). This finding reflects the safety climate literature related to feeling comfortable engaging in safety behavior in the presence of co-workers and supervisors.

Fourth, in HROs like wildland firefighting, safety behavior often consists of communicating concerns, and members must feel that they can voice concerns without encountering social costs. Therefore, workgroup leaders should receive training about the kinds of behaviors and attitudes that facilitate and inhibit open communication among members. This training could be based on safety climate research, which shows predictive relationships among specific behaviors and attitudes and how they contribute to the feel of workgroup interaction environments.

Recommendations for Crew Leaders

Findings from both studies affirmed the importance of crew level activities for implementing safety and developing firefighter experience. Study One showed that Manzanita and West Fork each maintained different communication and learning models that involved fostering mentorship and gaining practice with asserting authority, respectively. These learning models each contributed to the distinctive feel of the crew environments, and served the crews in different ways. Related to the feel of the crew environments, Study Two findings showed that open communicative exchange on crews contributed to members feeling comfortable voicing their concerns, and avoiding pressure to engage situations when safety was not in place. From these findings, I next describe how organizational leaders and crew leaders can foster consistent communicative routines, and learning from in-the-moment action.

Consistent communicative routines. The two studies in this project illustrated the importance of consistent communication routines in contributing to a comfortable and safety-conscious crew environment. A communicative crew

environment is particularly important for crews that have high turnover, and for crews which have inexperienced members. When communicative routines (such as AARs or informal debriefings) are conducted on a regular basis within the crew, members who are unfamiliar with each other (e.g., due to high turnover) can become more comfortable voicing concerns as they get to know their crew members. Also, when inexperienced members are encouraged to talk about their fire experiences and questions, they become accustomed to voicing their questions and concerns. Consistent communication routines help to create a communication environment that facilitates safety.

How leaders can facilitate the crew's communication environment. A communication forum plays an important role in helping members deepen their experience through sensemaking processes. The after action review (AAR) is one example of a possible communication forum that crews can draw upon. My findings show several recommendations for managers that would enhance the efficacy of this type of routine.

First, members must share and accept the value of the routine. Crew leaders can facilitate their members' acceptance of the routine by demonstrating their own value of it. If managers take the routine seriously, then they will set the example for how other members interpret the routine's value.

Second, managers should foster a comfortable communication environment so that members feel welcome to contribute openly to the discussion. Crew leaders can accomplish this by encouraging (but not forcing) members to participate. For

example, crew leaders can positively reinforce member participation by thanking members for sharing, by asking follow-up questions that encourage more discussion with the participating member, and by sharing their own questions and insights in ways that demonstrate the spirit of what the routine aims to accomplish (e.g., communicative openness on the crew). It is important that the crew environment be free of judgment so that members feel they can talk about anything, including their mistakes, which is crucial for HROs that are "preoccupied with failure."

Third, findings from Study One showed the importance of having the communicative routine be a consistent aspect of crew life. Manzanita members expected to debrief after every work shift, regardless of what occurred that day. For this reason, members said they actively thought about questions and topics to discuss as they engaged in their work. Therefore, by making sure that the routine is conducted on a consistent basis, crew leaders demonstrate the importance of the routine. Members know they will be expected to participate to the routine, and as a result, will hold themselves accountable to finding topics to discuss.

Learning from in-the-moment action. Findings from Study One showed the importance of in-the-moment-action in generating experience for West Fork members. West Fork members were highly experienced and were challenged to take on independent assignments and high levels of responsibility. Many of the members had moved beyond a mentorship model of communication and learning and were focused on honing their skills at thinking independently like experts. Thus, helping members to develop skills with their in-the-moment action was a crucial step toward

deepening expertise. Crews with highly experienced members, and crews whose members have high collective tenure, can benefit from providing members with opportunities to manage in-the-moment action.

How crew leaders can facilitate learning from in-the-moment action. First, members should be allowed opportunities for tactical experimentation. This means that they should be given assignments challenging them to step out of their "comfort zone." Crew leaders can provide members with chances to be autonomous in deciding which tactics to implement. Opportunities for autonomy cultivate independent thinking because members carry the weight of their responsibility and decisions. Crew leaders can facilitate autonomous action on these types of crews by also leveling the hierarchy of the crew such that all members are given decision-making latitude and are granted authority and flexibility to act autonomously on a regular basis on the crew.

Second, tactical experimentation provides members with the chance to see firsthand which actions work and which do not. Having opportunities to make mistakes is important here because the firsthand observation helps members to embody the knowledge. For example, West Fork members talked about experiences in which they had to change the ways they implemented escape routes and safety zones in spatial terrain due to having to narrowly escape flames. These experiences could be considered "mistakes," even though the tactics made sense in the moment. Thus, through autonomous action and tactical experimentation, members discovered new insights about which characteristics to prioritize when designating a safety zone.

Crew leaders can foster tactical experimentation on crews by first knowing members' skills and experience levels, and then by assigning fire assignments to members that will push them slightly beyond their skill levels. However, it is important to note that crew leaders must have thorough knowledge of their crew members' experience levels because pushing them too far beyond their capabilities could place members in situations that they are not equipped to handle.

Limitations and Future Directions

Before discussing the limitations to this project, I will first describe aspects of the project that worked well. First, for Study One, I collected critical incident narratives about members' coorientations with other firefighters. The critical incident approach was useful because it captured events from the participants' own points of view and represent how they view reality (Gremler, 2004). These critical incidents not only re-counted communicative interactions, but they also revealed how participants felt about those interaction and what they learned from them. Thus, in an HRO context, it was important to see how members incorporate their firsthand communicative interaction experiences into their body of knowledge. Second, my qualitative findings yielded interesting findings about how firefighters safely manage the spatial landscape of wildland firefighting, and revealed that close-call experiences were important for members to gain a tangible, material awareness of firefighting terrain. Third, the qualitative findings compared two functionally similar crews, which enabled me to draw important contrasts between them, and to notice certain defining aspects of each crew. Had I only interviewed one crew, I might have missed

several important details. Finally, for the quantitative study, I was able to gather a substantial sample from the wildland firefighting community, and participants frequently noted in an open-ended comments field that they thought the survey was interesting and necessary. This positive response from the wildland firefighting community indicates that they feel this work has potential to be valuable and beneficial to them.

There were several areas where the studies could have been stronger. In this section, I highlight key limitations and describe how those limitations could be addressed in future research. A few additional ideas for future research are discussed.

Study One

First, Study One relied on critical incident narratives about interactions that participants engaged in with other members. Future research could supplement this method with direct observation of interactions (or routines). Including observation of interactions would allow the researcher to further triangulate the findings because it would provide more complete information about interactions aside from the details that were leveled and sharpened from the participant's point of view.

Second, in retrospect, the critical incident stories did not capture as much detail as I would like, specifically relating to members' accounts of routines and uses of space. Direct observation of some of the space-related tasks would have been prohibitively difficult. However, it seemed like shortcomings in the data regarding space and routines could have been improved with further probing questions. Members appeared to take spatial configurations of safety zones and escape routes

for granted—treating space as simply one aspect of implementing the safety rules, rather than a material reality. Members who talked about space in terms of material reality (e.g., discussing how experiences of moving across space were tied to strong sensory experiences) were those who had a close call of running from the fire. Based on those experiences, the consequences of inadequately configuring their escape routes and safety zones in the spatial fire environment were tangible, not conceptual. It would have been useful to understand more about spatial awareness in general, both from the less-experienced members who seemed to only have a conceptual awareness of space and from members whose close call experiences had given them a tangible awareness of it. Future research could examine HRO members' awareness of space and safety rules and routines shape the ways space is understood and configured. In particular, it would be useful to understand more about the kinds of experiences that generate a tangible awareness of space. Thus probing questions could cue members to think about the sensory and emotional aspects of their experiences, such as physical fatigue, fear or excitement. Future research in this area could examine whether members must experience a close call in order to understand how space affects them in high hazard work. What are other experiences by which spatial awareness is gained? For example, how is gaining spatial awareness different for HRO members who work in distributed environments (e.g., wildland firefighting) versus container-like HROs (e.g., aircraft carriers, nuclear power plants, or oil platforms)?

Third, given the importance of social factors that inhibit safety climate (Study Two), it would have been helpful to understand more about the sources of social costs in Study One's Manzanita and West Fork. While I asked participants to talk about expectations on their crews and the kinds of behaviors that were rewarded, it would have been helpful to ask interviewees about behaviors that were specifically tied to social costs. West Fork members did mention clear behavior expectations, rewards and social costs. However, nearly every interviewee of the Manzanita crew portrayed the crew in a positive light. In order to move beyond the uniformly positive portrayals of Manzanita, and to gain a fuller understanding of the crew and its *texts*, it would have been useful to ask about experiences in which members were in conflict with one another. Conflict situations would potentially highlight further values of the crew; they also would lend clarity and precision to the values that members frequently mentioned. On this basis, future research focused on crew texts should attempt to gather not only the aspects of the workgroup that all members share, but also accounts about aspects of the crew on which members disagree.

Fourth, both Manzanita and West Fork appeared to be unique crews. West Fork was unique for their high experience level and high overall tenure of members on the crew, while Manzanita seemed to be unique for its commitment to creating a mentorship-based crew environment. It is likely that most crews throughout the wildland firefighting organization are neither as experienced (or independently acting) as West Fork, nor as cohesive and communicative as Manzanita. While interviewing two crews was tremendously valuable for providing points of contrast

between them, the results seemed to indicate the two crews were essentially opposite from one another in multiple ways (e.g., interactive versus autonomous, etc.). If there were more crews involved in the Study One, it would have been possible to better situate the findings to determine how important some of the differences were between the crews. For instance, interviewing a third crew that blends elements of, for example, Manzanita's interactivity and West Fork's autonomy, might have further elucidated the degree to which autonomy and interactivity truly defined the workgroup's identities. Future research on coorientation and texts in HRO workgroups should include interviews with more than two comparable crews in order to identify a broader range of crew interaction environments, but also to better understand which elements are common among crews, and which elements most powerfully shape crew collective identities.

Study Two

First, Study Two achieved relatively equal response rates from hotshots, helitack/rappel and engine crews presumably because I was able to access these populations through the commitment of national- and regional-level agency representatives who influenced the spread of the survey to those three types of ground crews. However, there were comparatively low response rates from Type 2 crews. This is likely because they were embedded within Forest- and District-level chains of command and were not subject to oversight by the central agency representatives that I contacted. Thus, the population was significantly more difficult to reach. The low response rate of Type 2 crews is a limitation because statistical

comparisons between that category of firefighters and the other fire crew types might have been less trustworthy. Also, the low response rate of Type 2 crews might point to important ways that Type 2 crews are different in disposition as compared to the other three crew types. Differences in disposition would be important to capture because those characteristics might influence other aspects of the crew interaction environment. For example, let us assume that all crew types had equal opportunity to take the survey; if the low response rate of Type 2 members was because they were not interested in participating in the survey, then this could indicate that they might not be very participative in general, including in their crews. Thus, they could potentially have a different kind of overall disposition toward participation than hotshots, helitack and engine crew members. Alternatively, if lack of participation in the survey was due to a lack of permission to take it, then it could be inferred that Type 2 crews generally experience more managerial control than do the other crew types, which would be an important crew condition contributing to the interaction environment, and by extension the safety climate. However, without adequate data, these comparisons cannot be made with certainty.

Second, most of the respondents were disproportionately high in experience because the early fall timing of the survey meant that I missed the seasonal college student firefighting work force. Therefore, the survey measures might not reflect the views of firefighters lower in the chain of command. Thus, future research should be aware of and adequately plan for the employment cycles of organizations that have seasonal workforces. One potential research idea is to repeat the survey, conducting it

at the height of the seasonal employment cycle, and assessing how the hypothesized relationships and SEM models are similar and different to Study Two's assessment of the generally highly-experienced firefighters.

Third, the items on the survey measured the group level, but more than two thirds of the cases were single respondents representing a crew. This limitation might best be addressed by gathering group-level data in a different way. Instead of using an online survey, it might have been advantageous to visit some crews directly. For example, numerous hotshot crews and engine crews submitted responses from two or more members, while helitack and Type 2 crews tended to submit responses from a single representative. Thus, knowing that it is more likely for multiple members of hotshot crews and engines to respond to the survey, a researcher could focus attention on personally visiting the base stations of helitack and Type 2 crews. Another option would be to gather data while entire crews are together in one place—such as on a large fire incident when crews sometimes have to stage for long periods of time before being assigned to the fireline. During the staging time, crews could be asked to participate in the survey, and multiple responses would be likely.

Fourth, the internal reliabilities of survey measures were relatively low, which likely influenced the accuracy of the results. This might have been due to adapting the scales so that they measured the group level and assessed the wildland firefighting context. Thus future studies, in which measures require substantial adaptation, should be pilot tested first. A pilot test would allow the researcher to identify problematic items and scales, and make improvements to the instrument.

Fifth, the relationship between independence and task interdependence was an important factor that seemed to define the crew environments in Study One. Manzanita's communication activities appeared to be directly linked to their task interdependent functioning, while West Fork's autonomy was a defining aspect of that crew. In the context of Study Two, the relationship between independence and task interdependence was less clear. The findings showed that it was common for crews to rate themselves highly in both task interdependence and independence, which could indicate that the measures might not have been specifically assessing work styles specific to the group. Instead, the measures might have also been measuring the degree of collaboration typically required for firefighter tasks. Given the importance of task interdependence and independence in defining the workgroup environments and resulting communication patterns for West Fork and Manzanita, it is important to ensure that these variables are measures can specifically assess the workgroup; there are two potential ways to accomplish this: 1) Group process variables could further clarify the degree to which independence and task interdependence relate to aspects of the work tasks versus characteristics for how the workgroup organizes. For example, reports of high task interdependence combined with high cohesion might indicate that task interdependence is a characteristic for how the workgroup organizes, whereas reports of high task interdependence and low cohesion might point to the interconnectedness of work tasks in general. Similarly, reports of high independence and high group satisfaction might combine to indicate how the group organizes, while high independence and low group satisfaction might

point to problematic relationships among crew members. 2) Another way to capture independence and task interdependence at the workgroup level would be to use hierarchical linear modeling to assess variations between crews on these constructs and whether variations affect the defined outcomes.

Finally, the importance of prestige in both Studies One and Two point to the influence of the workgroup's collective identity in the wildland firefighting profession. Qualitative research could explore the defining elements of workgroup identity, the aspects of their crew membership from which members derive the most pride, the ways (and degree to which) members incorporate workgroup identity into their personal identity. This research could highlight ways that identity influences action, interaction and safety. On a related note, future studies could assess the degree to which members identify with their workgroup and the kinds of factors that workgroup identification is linked with in that context.

Conclusion

This two-study dissertation examined the notion of safety in wildland firefighting workgroups. I used an *initiation* mixed methods approach (Greene, et al., 1989) in which I integrated results from two studies for the purpose of understanding a phenomenon more completely than one single method would allow. I used two perspectives to examine the concept of safety: high reliability organizing (Study One) and safety climate (Study Two). The studies yielded different, but complementary insights. Following a situationalist position, I remained true to the assumptions of both paradigms (Greene, et al., 1989; Kidder & Fine, 1984). When integrating the

results from the two studies, I looked for areas in which the findings from the two studies overlapped with and diverged from each other and focused my analysis in those areas in order to ask new theoretical questions.

The findings from both studies showed that research on the wildland firefighting organization can expand HRO theory due to firefighting's unique, often emergent structure. Wildland firefighting is a somewhat messy version of a high reliability organization; it is almost an opposite organizational model than an aircraft carrier flight deck (Weick & Roberts, 1993), upon which some foundational HRO theorizing is based. Flight decks are deeply stratified, members have limited decision latitude, and operations occur in a spatially confined, container-like environment. In contrast, wildland firefighters operate in decentralized ways when suppressing very large fires, members have varying degrees of decision making latitude (often a tremendous amount), and fire spaces are always changing due to increases in fire size and the various terrain features on which they occur. Therefore, the emergent nature of firefighting can extend HRO theorizing to include additional factors that are important in generating reliable and safe outcomes. For example, Weick and Roberts describe that aircraft carrier flight deck personnel organize in tightly circumscribed roles while working toward a collectively held goal of what the organization aims to accomplish. The container-like structure of the aircraft carrier contributes to its members' abilities to share a collective goal. In contrast, wildland fires are often scattered across large geographic areas and varied terrain. Members might not be able to visualize larger goals for the firefighting effort; therefore organizing processes

might focus on local levels of activity as the primary theoretical (and practical) focus because members' immediate surroundings—and social interactions—are most perceptible and immediate.

Most importantly, this dissertation has emphasized the importance of bringing a communication perspective to safety. The communication constitutes organization (CCO) approach emphasizes how members talk safe actions into existence (not just *situations*). For CCO, the communicative interaction is the unit of analysis as members talk into existence which actions to take together. One crucial contribution of CCO to the HRO and safety climate literatures is CCO's direct acknowledgement of the role of organizational elements (e.g., rules, routines and material space) in communicative processes of organizing. Hence, the organization is made present through interactions that interpret and clarify the organization while also informing the action. This process was unpacked in Study One as members directly invoked organizational rules and local routines in their safety and task-based interactions. Study One also showed that the characteristic interaction patterns that workgroups perpetuate influence the feel of the workgroup interaction environment, which has a direct influence on members' feelings of comfort with regard to voicing concerns and feeling pressure to take risks (the focus of Study Two).

At the beginning of Chapter One, I stated that the South Canyon fire marked a turning point in the wildland firefighting profession because it brought attention to the strong link between social interaction and firefighter safety. This project explored this important link from two different perspectives. The high reliability organizing

perspective employed a fine-grained qualitative analysis, which enabled me to unpack how interactions within workgroups generated and maintained particular kinds of interaction patterns (e.g., mentorship, conflict), as well as particular ways of implementing safety (e.g., incorporating dialogue, or acting autonomously). Findings suggested that firefighters should develop several types of communication skills in order to handle the variety of interactions they might encounter on the fireline. They should gain skills with turning their communication into action, and gaining authority; they should also understand when dialogue interactions are beneficial. The second study used quantitative methods to examine the safety culture of the organization as a whole. These findings lend broader insight into the common combinations of workgroup factors that influence the communication environment of crews. It is important to understand how the crew environment enables and constrains members' comfort with communicating questions, concerns and insights because the decision to communicate a concern--or to keep it quiet--might mean the difference between life and death.

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